

An Introduction to Wetland Restoration, Creation, and Enhancement

A Guide for the Public Containing:

- Background on wetlands and restoration
- Information on project planning, implementation, and monitoring
 - Lists of resources, contacts, and funding sources

Developed by the Interagency Workgroup on Wetland Restoration:

**Environmental Protection Agency, National Oceanic and Atmospheric Administration,
Army Corps of Engineers, Fish and Wildlife Service, and
Natural Resources Conservation Service**

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(future)

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LETTER TO THE READER

Over the past 200 years, more than 50 percent of our Nation's wetlands have been lost and many of the remaining wetlands are degraded. These losses and alterations compromise the important benefits provided by wetlands including protecting water quality, providing habitat for a wide variety of plants and animals, and reducing flood damage. While *preserving* remaining wetland resources is critical to our nation's environmental health, *restoring* wetlands also is essential to ensuring the quality of aquatic systems. Because wetlands are so important to the earth's ecosystems and human society, the Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), Fish and Wildlife Service (FWS), Natural Resources Conservation Service (NRCS), and Army Corps of Engineers (Corps) worked together to develop this document designed for people wishing to support or undertake wetland recovery projects.

Developing a guide on wetland restoration, creation, and enhancement applicable across the nation is difficult for a number of reasons. First, the terms "restoration", "creation", and "enhancement" encompass a wide range of activities related to establishing or re-establishing wetlands. Second, climate, region, wetland type and local conditions determine the type of wetland project that is most appropriate. Third, the goals of people undertaking wetland projects vary widely and these goals influence what kind of activities are best suited to a particular site. Given the broad scope of the subject matter, this document is designed to achieve two goals:

- Introduce non-technical readers to the basics of wetland projects including planning, implementing, and monitoring, and
- Direct interested persons to documents and resources specific to a particular region or wetland type.

The document is organized around these two goals. The text gives information on wetlands, background on the practice of restoration, and information on the process involved in undertaking a wetland project. The appendices provide resources for finding additional information and advice on restoration, creation, and enhancement projects.

Many documents about restoration and related activities are technical or scientific in nature and are designed for experts. This document, however, is not a scientific paper. It is designed specifically for individuals, community groups, municipalities, or others who have little or no experience in the restoration field. We have written to a general audience for several reasons:

- Many EPA, NOAA, FWS, and NRCS programs already support grassroots wetland recovery efforts, so information on wetland restoration for the general public is consistent with those programs.
- Most land in the U.S. is in private ownership; significant increases in wetland quality and quantity can be achieved if private landowners restore wetlands on their property.
- Non-technical people interested in restoration need documents that direct them toward the

- sources of information and expert advice that may be required to do a project. Restoration is an important, growing environmental field. The general public can benefit from access to basic information about restoration, and may become encouraged to become involved in and support restoration projects.

As you read this document, it will become clear that wetland projects vary considerably in size and complexity. In some cases, one person's efforts (fencing out cows, mowing instead of tilling, or eliminating the use of pesticides) can substantially improve a degraded site. On the other hand, teamwork and the help of specialists is usually required for creating new wetlands or restoring sites with extensive damage. In her book *Restoring Streams in Cities*, Ann Riley (1998) states that most restoration projects require teams of people with expertise in areas such as ecology, hydrology, engineering, and planning, among others.

Many landowners enroll in federal or state programs in which the public agency puts together a team of specialists who help with the restoration work. Other landowners or citizen groups may not be eligible for these programs or simply may want to organize the project themselves. Whether you are enrolled in a wetland restoration program or are organizing a wetland project yourself, this guide will help you understand what types of people and resources to consult in order to plan, implement, and monitor your wetland project.

The agencies who have worked on this informational document want it to be as useful as possible. Please give us your thoughts and comments on the information provided here. Write us or e-mail us care of:

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Figure 1. Photograph of People Restoring a Wetland (Future)

PART 1. INTRODUCTION

Why Restore Wetlands?

The public's interest in the renewal of natural ecosystems has grown steadily during the past few decades. While preservation of habitat is a key to environmental health, there is a growing awareness that restoration is essential to recover ecosystems that have been degraded or destroyed. Wetland habitats are the focus of many restoration efforts because, over the past 200 years, the area and health of wetlands has declined significantly. Less than 46 percent of the original 215 million acres of wetlands, the estimated acreage of wetlands that existed in the contiguous U.S. when Europeans arrived, still remain. Prior to the mid-1970s, the draining and destruction of wetlands were accepted practices. Many wetlands altered by humans were drained to support agricultural uses, while others were filled for urban development, diked for water impoundments or to diminish flooding, or dredged for marinas and ports. Indirect impacts from pollutants, urban runoff and invasion by non-native species continue to degrade and destroy wetlands.

Scientists and policy makers also recognize the value of wetland restoration. In 1992, scientists completed a study for the National Research Council that called for the development of a national wetlands restoration strategy. Since then, federal agencies have worked with partners toward the goal of a net increase of 100,000 acres of wetlands per year by 2005. This goal will be reached only through carefully planned and implemented restoration, creation, and enhancement projects that add ecologically valuable wetlands to the landscape. States and the federal government are funding and conducting large-scale ecosystem restorations, such as the South Florida/Everglades Ecosystem Restoration, which are contributing to this goal. However, without the support of citizens and local groups around the country the 100,000 acre per year goal cannot be reached.

For many decades, citizens have been restoring wetland habitats through non-profit organizations such as The Nature Conservancy and Ducks Unlimited. These organizations have restored thousands of acres of wetlands and have encouraged people all over the U.S. to participate in wetland recovery projects. In addition, citizens have become involved in restoration through government programs, such as the U.S. Department of Agriculture's Wetland Reserve Program. Despite these efforts, the nation is still losing more wetlands than it gains each year. This document is designed to support and further encourage landowner and community-based wetland restoration.

What are Wetlands?

Wetland Characteristics. Wetlands are unique ecosystems that are often transition zones between aquatic (deep water) and terrestrial (upland) systems. They also may be isolated waters, surrounded by upland habitat. They may be wet year round, wet during certain seasons, or wet during part of the day. The federal Clean Water Act (1972) defines wetlands as:

"areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

In addition to bogs and swamps, wetlands include tidal marshes, prairie potholes, seagrass beds, forested wetlands, and seasonally ponded sites, such as vernal pools. Some of these wetland types, such as seasonal wetlands that are dry much of the year, may not always appear to be wetlands. The National Research Council (1995) lists several major classes of U.S. wetlands and some plants associated with each:

- Freshwater Marsh--grasses, sedges, herbs;
- Tidal Salt and Brackish Marsh--salt tolerant grasses, rushes;
- Prairie Potholes--grasses, sedges, herbs;
- Fens--sedges, grasses, shrubs, trees;
- Bogs--sphagnum moss, shrubs, trees;
- Swamp Bottomland--cypress, gum, red maple; and
- Mangrove Forest--black, red, white mangroves.

Although wetland types are diverse, they all possess several ecological characteristics that distinguish them from upland or other aquatic ecosystems. Specifically, wetlands are characterized by unique hydrologic, soil (substrate), and biotic conditions. The hydrological regime, which is determined by the duration, flow, amount, and frequency of water on a site, is typically the *primary factor* driving the other ecological elements of the system. A site has wetland hydrology when it is wet enough to produce soils that can support hydrophytic vegetation ("water-loving" plants that are adapted to waterlogged environments). Wetland substrates are called hydric soils, meaning they are saturated with water for all or part of the year. Saturated soils become anaerobic (without oxygen) as water drives the oxygen out of the spaces between soil particles. When soils become anaerobic, they change significantly in structure and chemistry. These factors all make wetland soils hostile to terrestrial plants.

As a result of waterlogged, anaerobic conditions, wetlands are dominated by hydrophytic plants that are *specifically adapted* to these demanding conditions. The wide diversity of wetland plant species includes emergent plants (such as cattails, sedges, and rushes), submerged plants (pondweeds, eelgrass), and floating plants (such as duckweed). Wetland plants also include trees (such as cypress, red maple, and swamp oak), shrubs (such as willows and bayberry), moss, and many other vegetation types.

Because they exist where land and water meet, wetlands are often used by animals from both wet and dry environments. A number of invertebrate, fish, reptile, and amphibian species depend on wetland water cycles to survive or complete their lifecycles. For example, nearly all amphibians, approximately 75 percent of all commercial marine fish species, and at least 50 percent of migratory birds use wetlands regularly. See Technical Appendix T-II for more information on these attributes of wetlands.

Wetland Classification. Scientists have developed a number of wetland classification hierarchies to describe wetland types. A well-known scheme, developed by Cowardin, et al. (1979) for the Fish and Wildlife Service (FWS), has become the federally-accepted standard system for classifying wetland types (see Box 1). Cowardin, et al. state, “Wetlands are defined by plants (hydrophytes), soils (hydric soils), and frequent flooding. Ecologically related areas of deepwater, traditionally not considered wetlands, are included in the classification as deepwater habitats.”

BOX 1: Definitions of Wetland Systems from Cowardin, et al. (1979)

Marine:

Open ocean overlying the continental shelf and associated high-energy coast line. Examples of wetland types within this system are subtidal and intertidal aquatic beds, reefs, and rocky shores.

Estuarine:

Deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partially obstructed, or sporadic access to the ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land. Examples of estuarine classes include subtidal and intertidal emergent wetlands, forested wetlands, and rock bottom.

Riverine:

Wetland and deepwater habitats contained within a channel with two exceptions: 1) wetlands dominated by trees, shrubs, persistent emergent plants, emergent mosses or lichens, and 2) habitat with water containing ocean-derived salts in excess of 5 ppt (parts per thousand). Rivers and streams fall within this system and subsystems include tidal, perennial, or intermittent watercourses.

Lacustrine:

Wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) less than 30 percent areal coverage by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens; and 3) total area exceeds 8 hectares (20 acres). Lakes typify lacustrine wetland systems.

Palustrine:

All nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 5 ppt. This system also includes wetlands lacking such vegetation if they are less than 8 hectares, lack wave-action or bedrock shoreline features, and, at the deepest spot are no deeper than 2 meters at low water. Examples include ponds, bogs, and prairie potholes.

Figure 2. Cowardin diagram of Palustrine wetland (Future)

Figure 3. Photographs of Different Wetland Types. (Future)

The Importance of Wetlands

The loss and degradation of wetlands in the U.S. has resulted in a decline in the important benefits that wetlands provide to society. These benefits or functions usually link to goods and services important to society. Some of the benefits wetlands provide include:

- Healthy fisheries. Since approximately 75 percent of the fish and shellfish that are commercially harvested are dependent on estuaries and their wetlands, the value of wetlands to commercial fisheries is enormous. In California alone, the seafood industry generates approximately \$800 million in sales annually. Virtually all freshwater species of fish are dependent to some degree on wetlands, often spawning in marshes adjacent to lakes or in riparian forests during spring flooding. These species are sought by recreational anglers, who spent \$38 billion in 1996 to pursue their sport.
- Support for birds and other wildlife. Wetlands are probably best known for their value to waterfowl. The freshwater wetlands in the prairie pothole region of North America support an estimated 50 to 80 percent of the continental waterfowl production each year. The loss of wetlands in this region, which is estimated to be more than 50 percent of the original wetland acreage occurring at the time of settlement, has been considered a major factor in the decline in nesting success of duck populations in North America. Wetlands also support a wide diversity of other birds. Eighty percent of America's breeding bird population and more than 50 percent of the 800 species of protected migratory birds rely on wetlands.

In addition to birds, other wildlife makes its home in wetlands. Reptiles such as turtles, lizards, and snakes, and amphibians such as toads, frogs, and salamanders are important residents. Nearly all of the approximately 190 species of amphibians in North America depend on wetlands for breeding. Other wildlife associated with wetlands include species such as muskrat, beaver, mink, raccoon, marsh and swamp rabbits, numerous mice, voles, shrews, lemmings, and other small mammals. Large mammals also rely on wetlands. Whitetail deer often depend on wetlands such as white cedar swamps and other forested wetlands for winter shelter and food.

- Erosion control. By dissipating wave energy and stabilizing shorelines, wetland vegetation buffers the adjacent upland from wave action and intensive erosion. Unprotected shorelines have been found to erode four times as fast as vegetated salt marshes.

- Flood damage reduction. Wetlands intercept runoff and store stormwater, thereby changing rapid and high peak flows to slower and smaller discharges over longer periods of time. Because it is usually the peak flows that cause flood damage, the effect of wetlands is to reduce the danger of flooding. A classic study by the Army Corps of Engineers in the Charles River Basin in Massachusetts estimated that the loss of 3400 hectares (approximately 8100 acres) of forested wetlands would result in an annual increase of millions of dollars in downstream flood damage.
- Good water quality. Wetlands are known for their ability to capture sediments and filter pollutants, which improves water quality. For example, spring floods often carry very turbid water which, if not for the filtering that occurs in downstream wetlands, could deposit sediment that would smother plants and fish eggs. In addition, wetlands constructed to treat municipal runoff require only a fraction of the construction and operation budget of a conventional system.
- High biological productivity. Many wetlands are highly productive ecosystems in large part because they are rich in organic matter and nutrients. These nutrients support organisms within the marsh, but in many instances the nutrients are also transferred to nearby aquatic systems (lakes, rivers, and estuaries), enhancing the productivity of these systems and supporting human uses such as offshore commercial fisheries.
- Biodiversity protection. Wetlands support a great diversity of species and many of the species are unique and rare. Of the 1,082 U.S. plant and animal species listed as threatened and endangered as of May 31, 1997, 499 species (46 percent) are wetland-associated. These organisms are important to ecosystem function and, ultimately, for the health of the environment upon which humans depend. Among this vast diversity are many plant species used for food, drugs, and other commodities. There are most likely other beneficial organisms yet to be discovered.
- Aesthetics and recreation. Many recreational activities take place in and around wetlands. Hunting and fishing are popular activities associated with wetlands. Other recreational activities in wetlands include hiking, nature observation and photography, canoeing, and other boating. Many people simply enjoy the beauty and sounds of nature and spend their leisure time near wetlands observing plant and animal life. Wetlands are also important places for outdoor study and for gaining an appreciation of natural history and ecology. In residential areas, wetlands often provide a privacy barrier between neighbors. Properties bordering wetlands often have higher property values than those that do not. Urban wetlands are typically some of the last remaining pieces of “natural habitat” providing residents some sense of wildness and open space.

A primary goal of wetland recovery projects is to preserve and restore wetland benefits by re-establishing *natural ecological processes*. Some wetland functions can be mimicked with engineered structures, but engineered methods typically do not provide the maximum ecological benefit. For example, instead of re-establishing native vegetation on wetland edges to control erosion, rock boulders (rip-rap) or a cement wall could be used to armor the bank. These engineered methods limit erosion for a time, but they do not provide for the other ecosystem benefits of natural vegetation, such as filtering pollutants and providing fish habitat. For a more detailed list of wetland functions, see Technical Appendix T-I.

PART 2. WHAT IS RESTORATION?

Definitions

The terms “restoration”, “creation”, and “enhancement” have been defined a variety of ways. The following commonly-accepted definitions for these terms, based on Lewis (1990), will be used in this document:

- **Restoration** - Returning a degraded wetland or former wetland to a pre-existing condition or as close to that condition as is possible.
- **Creation** - Converting a non-wetland (either dry land or deep water) to a wetland.
- **Enhancement** - Increasing one or more of the functions performed by an existing wetland beyond what currently or previously existed in the wetland. There is often an accompanying decrease in other functions.

Restoration and enhancement projects may be difficult to distinguish from each other, because both can encompass activities in existing degraded wetlands. According to the definitions above, restoration entails returning a wetland to a former state (e.g., filling a ditch so that a drained wetland becomes flooded again), while enhancement means changing the wetland so that one or more functions are increased beyond their original state. An example would be diverting a small stream into a wetland so that the area has deeper water.

Wetland restoration is usually preferred over enhancement because enhancing a wetland in one way often degrades it in another way. For example, adding more water to a wetland may create better habitat for fish, but it will decrease the ability of the wetland to hold flood waters. This trade-off is particularly true for enhancement in relatively undisturbed wetlands. Some common examples of the trade-offs that can occur with wetland enhancement include loss of fish habitat when salt marshes are impounded to provide waterfowl habitat, decreased water storage when seasonal wetlands are flooded to increase aquatic habitat, and loss of colonial waterbird habitat when mangroves are removed to provide shorebird habitat. When wetland enhancement is undertaken, the project goals should include minimizing any decrease in existing wetland functions.

Wetland restoration also is preferred over creation because putting a wetland where it did not exist before is a difficult undertaking. The primary challenges in creation projects are

bringing water to a site where it does not naturally occur and establishing vegetation on soils that are not hydric. While creation is possible, it typically requires significantly more planning and effort than restoration projects, and success is difficult to predict. Many attempts to convert uplands to wetlands result in wetlands that do not closely resemble natural systems and that provide limited wetland functions (valuable upland habitat is lost in the process as well). Creating wetlands from open water is less difficult with respect to establishing a water source, but it often requires placing dirt or other fill into existing aquatic habitats, which means destroying one kind of aquatic habitat to create another. While this trade-off sometimes can be justified ecologically, the engineering and regulatory challenges of these projects are so complicated that professional expertise and oversight are almost always required. Under certain circumstances, creation or enhancement may be the best option (see Box 2 for an example), but for the most part, returning a degraded wetland or former wetland to its previous condition is the most ecologically beneficial and economical way to improve wetland resources.

BOX 2: Created Wetlands to Treat Urban Runoff

In the Sligo Creek Watershed of Montgomery County Maryland, the Metropolitan Washington Council of Governments (COG) worked with many groups and agencies to build created wetlands that capture stormwater runoff from local urban development. The created wetlands control the amount of water reaching Sligo Creek and allow the sediment and other pollutants to settle out before the water reaches the Creek. Created treatment wetlands are ideal for controlling the increased runoff and pollutants generated by development in watersheds. Because the created wetlands helped improve water quality and establish more natural flows to Sligo Creek, COG and local groups were able to complete stream restoration in the Creek itself. They have restored the natural channel shape, replanted native tree species, and reintroduced native fish and amphibians.

One additional term common in discussions about wetland restoration, creation, and enhancement is **mitigation**. In a general sense, mitigation means reducing environmental damage by avoiding, minimizing, and compensating for activities that damage or destroy protected resources. In a wetland context, “mitigation” is usually short for “compensatory mitigation” and means wetland restoration, creation, enhancement, or some other action undertaken for the specific purpose of compensating for the damage or destruction to another wetland area. When wetland restoration or a related activity is undertaken as mitigation, there are usually a number of requirements that must be met to ensure that the wetland activity provides adequate compensation for the associated wetland loss.

Discussing the regulatory requirements of compensatory mitigation is beyond the scope of this document. More information on topics specific to compensatory mitigation can be obtained from agencies involved in wetland regulation, especially the Environmental Protection

Agency (EPA) and the Army Corps of Engineers (Corps) (see Federal agency web sites in Resource Appendix R-III).

Planning, monitoring, and long-term management, which are important for all wetland restoration, creation, and enhancement activities, are especially important for wetland mitigation projects.

Two Approaches to Restoration

Restoration practitioners typically implement only the actions necessary to re-establish natural wetland processes on a site. The first, and preferred, method for renewing functions is to remove the factors causing wetland degradation or loss and let nature do the work of restoration. This method is often called the **passive approach**. For example, if wetland vegetation and water quality are degraded primarily as a result of cattle grazing, then removing the cows may be the only activity needed to restore the wetland system. Passive methods allow natural regeneration of wetland plant communities, natural re-colonization by animals, and re-establishment of wetland hydrology and soils. Passive approaches are most appropriate when the degraded site still retains basic wetland characteristics and the source of the degradation is an action that can be stopped. The success of passive methods usually depends on an accessible source of water, the close proximity of wetland plants and animals, and a mechanism for bringing species to the restoration site. The benefits of passive methods include low cost and a high degree of certainty that the resulting wetland will be compatible with the surrounding landscape.

For many sites, passive wetland methods are not enough to restore the natural system and an **active approach** is necessary. Active approaches involve physical intervention in which humans directly control site processes to restore, create, or enhance wetland systems. The active approach is most appropriate when a wetland is severely degraded or when goals cannot be achieved in any other way, as is the case with wetland creation and most enhancements. Active methods include re-contouring a site to the required topography, changing the water flow with water control structures (i.e., weirs or culverts), intensive planting and seeding, intensive non-native species control, and bringing soils to the site to provide the proper substrate for native species. The design, engineering, construction, and costs for such work can be significant.

PART 3. TACKLING THE RESTORATION PROJECT

Have Someone Do the Project for You

Whether the project is relatively simple or very complex, there are two primary strategies you can take to getting the work done--have someone do the project for you or do the project yourself. There are a number of federal wetland restoration programs, in which landowners can enroll for help with a wetland recovery project. Federal programs provide technical and financial assistance to landowners, communities, and local governments interested in restoring native fish

and wildlife habitats, including wetlands, uplands, riparian, and in-stream habitats. Many people take this route to restoration. Information on federal programs is given in Resource Appendix R-II. Several states, non-profit organizations, and local governments have similar programs. Check with your state department of natural resources to determine whether local restoration programs exist.

If you don't qualify for a federal or state program, another project approach is to hire someone with experience in wetland restoration to put together a plan and a team for you. There are consulting firms and some non-profit groups around the country who either have the expertise in-house or can act as a wetland restoration contractor. Check the Association of State Wetland Managers' "Directory of Wetland Professionals" at <http://www.aswm.org>. or the Professional Certification section of the Society of Wetland Scientists' site at <http://www.sws.org> for lists of professional restorationists (and see Resource Appendix R-III).

Do the Project Yourself

If you choose to do the project yourself, you will want to assemble the people necessary to complete your wetland work. The type of technical advice and amount of physical help needed will depend on the project goals, the extent of degradation of the site, and the type of wetland; in short, it will depend on the complexity of the project. An example of a community-based project requiring moderate effort is described in Box 3, the Decker Lake Wetlands Project.

BOX 3: Decker Lake Wetlands Project—A Multi-Partner Effort

In Salt Lake County, Utah, non-native species were contributing to the degradation of Decker Lake. Youth Force, part of the Salt Lake County Service and Conservation Corps, decided to do something to help the Lake. The Salt Lake County Job Training Partnership Act and the EPA's Five-Star Restoration Program helped fund the effort. EPA's Region 8 office provided funding for a local naturalist who gave presentations on local ecology to the Youth Force crew and the community. With technical assistance from a Fish and Wildlife Service staff member, the Youth Force team pruned non-native tamarisk and removed *Phragmites* and other invasive plants from a 15 foot by 500 foot bank area next to Decker Lake. In addition to improving lake-side conditions, the Youth Force educated visiting groups about non-native species and attracted many other volunteers to help at the site.

For many projects, to accomplish the changes in hydrology, soils, and biota necessary to create or restore a functioning system, you will need assistance from local experts on wetland restoration. Resource Appendix R-I contains potential sources of information. You will most likely need funding for your project, too. See Resource Appendix R-II for a start on where to look for funding. Some sources of information, technical help, and funding include:

On-Line Resources. There are several on-line sources of restoration expertise. Through the “Directory of Wetland Professionals” maintained by the Association of State Wetland Managers at <http://www.aswm.org>, you may find experts willing to help you. The Society for Ecological Restoration (SER) will soon have an “Ecological Restoration Directory” that will be a “comprehensive database of U.S. ecological restoration expertise—local, regional, national and international individuals, organizations, agencies, and companies—as well as available training programs, workshops and education services.” This directory should be on-line in the year 2001. The SER site at <http://www.ser.org> lists Chapters and Regional Contacts and these contacts may be able to help you find local expertise. Another site with all types of restoration information and resources is the National Wetlands Conservation Alliance homepage at <http://www.users.erols.com/wetlandg/#des>. See their “Wetland Links” for a wide range of restoration resources. A valuable source of wetland information and help is the Society of Wetland Scientists site (<http://www.sws.org>). The “Wetland Links” section gives resources at the federal and state level, as well as universities, consultants, and training courses. Many government websites also provide restoration resources. See restoration websites at EPA, NRCS, National Oceanographic and Atmospheric Administration/National Marine Fisheries Service (NOAA/NMFS), and the Corps, for a start (see Resource Appendix R-III).

Agencies. Talk with public agencies to see if they have staff who can help you. You might begin with your local office of the U.S. Geological Survey (USGS), FWS, NMFS, EPA, or the Corps. In agricultural areas, check with the NRCS for restoration expertise. Your state or local natural resource agencies, conservation districts, or state departments of natural resources may have staff with experience in wetland restoration. Ask for help in developing your restoration plan, reviewing it, or in providing specific information on the ecology of the wetland type you want to establish. If the agencies you contact do not have enough time or expertise to help you, ask for other contacts they would recommend. Some agencies have programs for funding restoration projects (see Resource Appendix R-II).

Local Experts. Solicit restoration expertise from the local community. Post or send out flyers asking for volunteer experts in the community to help you. Many people with wetland restoration expertise are involved in wetland restoration efforts in their off hours. Not everyone who volunteers will have the expertise you need, so ask questions about what projects they’ve worked on, and look at the projects to see if they are meeting their goals.

Universities and Non-Profits. Check with the biology or environmental studies departments of local colleges and universities. They may offer ecological restoration courses or programs that could provide you with more background. The course instructors may be willing to help you with your project by providing technical advice and/or student volunteers. Local non-profit organizations may have restoration programs as well as access to advisors and volunteers. If local non-profits don’t yet have a restoration program, you might convince them to team up with you to plan and undertake your project. Consider such organizations as the Izaak Walton League of America, the local Sierra Club or Audubon Society, native plant societies, and watershed protection groups.

Several large non-profit groups are significant supporters of restoration work. The National Fish and Wildlife Foundation helps groups find money to finance environmental projects, Ducks Unlimited provides funds and expertise to protect and restore wetland habitat, and The Nature Conservancy is a valuable source of information on restoration, creation, and enhancement projects. Find contact information for these and other groups in Resource Appendix R-III.

The remainder of this document describes the three phases of a restoration project: planning, implementation, and monitoring. If you are having someone conduct the restoration project for you, you will not be using this information yourself, but knowing the process will help you ask the right questions and understand the work. For those doing their own projects, the following information gives a basic overview of the restoration process and provides some resources. This document cannot provide the specific information on local wetland types, site conditions, watershed land uses, or implementation that is necessary to actually accomplish a project. That information must be obtained from sources with specific local knowledge. Some of these sources are listed in the Bibliography (Resource Appendix R-I) and in Resource Appendices R-II and R-III.

PART 4. PLANNING

Why Plan?

Good planning is a critical, but often overlooked, stage of the restoration process. Inadequate planning is often cited as a major reason projects fail to restore self-sustaining, naturally-functioning systems. Here are just a few reasons thoughtful planning is so important:

- Planning will help you choose the best site to achieve your goals, or, if you already have a site in mind, planning will help you determine the most reasonable goals for your site.
- Planning will help you establish clear and feasible objectives given the factors that may constrain the project.
- Planning identifies the materials, labor, and activities that will be needed to achieve the project's goals.
- Objectives and target criteria established during planning direct the type of monitoring that will be needed.
- Clear goals and objectives will help you explain to other people, including potential funders, partners, and the local community, what you are trying to accomplish.

Not every project will require all of the planning steps described in this section, nor will everything in each step be needed. The extent of the planning required will depend on the condition of the project site and your goals. More complex projects require more planning.

Know Your Landscape

To plan a wetland project that will be compatible with adjacent ecosystems, you will need to understand the local landscape. If you have already chosen a project site, understanding the landscape will help you determine what is ecologically possible on your site. If you are looking for a site, understanding the landscape will help you choose the site most likely to achieve your goals.

All wetlands exist in a landscape that has an enormous influence on how the wetland develops and functions. As you begin planning a wetland project, look at the landscape and identify the major natural features and any patterns in the way these natural features occur. For example, is the area fairly flat, hilly, or sloped? These factors affect surface and groundwater drainage and ponding patterns. Are land uses in the surrounding landscape changing rapidly, as is often the case near eroding coastlines or in urbanizing areas? Rapidly changing land forms or land uses may have future negative effects on project sites. Do the wetlands occur throughout the landscape or are they concentrated in one place? The distribution of wetlands is influenced by natural features of watersheds, such as topography (elevation, aspect and slope), climate, precipitation patterns, soil types, groundwater, surface waters, floodplains, and vegetation communities. You will want to collect current information on the hydrology, soils, and vegetation communities in the watershed.

Maps with local topography and existing aerial photography can provide essential information on the primary sources of water in the watershed and the way wetlands are associated with them. Rivers, streams, lakes, bays, and the ocean are obvious sources of water that may have wetlands associated with them. Some wetlands are sustained by less obvious sources of water such as groundwater (springs, seeps, high water table) or rainfall and surface runoff. Obtain topography, drainage, and runoff information from the NRCS Field Office Technical Guides. Local water quality control districts, water management districts, or flood control districts (states often use different names) will have rainfall data and water level data for local water bodies. Look for data on the groundwater levels. The Federal Emergency Management Agency (FEMA) and local flood control districts have maps on the location and elevations of floodplains. These agencies can help you find out the frequency and magnitude of the flood events that occur in your community.

Soil maps for your watershed are available from the NRCS and are invaluable in locating where wetland soils exist or used to exist. Soil maps also often contain information about the location of springs, ponds, streams, and drainage ditches. Aerial photographs from the USGS or local aerial photography firms may provide data on some watershed features including the presence of wetlands and the amount and type of vegetation cover in an area. Information on local vegetation communities also may come from recent biological reports completed for planning agencies, Environmental Impact Statements, or other documents available from local planning agencies. Table 1 gives sources of information on soils, floodplains, and other watershed features.

Table 1. Where to Find Information on Your Watershed/Landscape and Site

Information Resource	Where to Find Information Resources
Aerial Photography	Local Geological Survey (USGS) office, NASA (satellite photos such as those from the Thematic Mapper); Farm Services Agency (FSA); local aerial photography companies; state natural resource agencies.
Flood elevations and floodplains	County, city, or town zoning and planning offices; Federal Emergency Management Agency (FEMA) Flood Hazard Maps; District offices of the Army Corps of Engineers; state natural resource agencies.
National Wetlands Inventory (NWI) Maps	Local FWS Office; Local USGS office; District offices of the Army Corps of Engineers; state Earth Science Information Center; find local contact information at: http://mapping.usgs.gov/mac/isb/pubs/forms/esicstat.html ; find the interactive wetlands mapper at: http://wetlands.fws.gov/ .
Soil Survey Information	Local office of NRCS; find the field office directory at: http://www.ncg.nrcs.usda.gov/perdir.html .
Topographic Maps	Local USGS office or USGS's "Map Finder" at: http://edcwww.cr.usgs.gov/Webglis/glisbin/finder_main.pl?dataset_name=MAPS_LARGE or call 1-800-USA-MAPS; local map or sporting goods stores.

Aerial photos are a valuable and commonly used tool to collect data on watershed features such as topography, drainage and ponding patterns, land uses, vegetation communities and coverage, and habitat fragmentation and loss. Aerial photos can not provide all of the information needed to evaluate watershed conditions; you will need to check with other sources to fully evaluate your watershed. Consult local agencies and other sources of information to get a full picture of current watershed conditions.

Figure 4. Photograph of Watershed. (Future)

In addition to information about present conditions, collect information on the history of the watershed for valuable insight into the ecosystems that used to be there and what factors have caused loss or degradation to wetlands in the area. There may be aerial photographs for the past several decades or other records of past watershed conditions that could provide some of this information. Reviewing aerial photos from several years probably will show that some features, such as topography, have not changed much but others, such as land use, vegetation communities and coverages, have changed significantly.

After considering natural conditions, identify human influences and constructed features. Roads, ditches, dams, and large areas of impervious surfaces such as parking lots, are all features of the landscape that could affect existing wetlands and proposed wetland projects. Adjacent or regional land uses may or may not be compatible with re-establishing a former wetland or with the goals of a wetland creation or enhancement. Typical land uses include urbanized lands (residential, industrial, commercial), agriculture, grazing, mining, forest harvesting, streams, lakes, wetlands, non-harvested forest, open grassland, or park/recreational open space.

Typically, urban and industrial areas may be sources of excess sediment and pollutants, such as oil and heavy metals, that wash off paved areas into streams and wetlands. Agriculture is often a source of pesticides and fertilizers that may harm wetlands. These land uses may impair the health of newly established wetlands. On the other hand, farms are capable of providing valuable adjacent upland habitat if there are uncultivated buffer areas between the wetland and the fields. Consider not only existing land uses, but also future changes to the landscape such as encroaching development. Local zoning and planning documents from cities and counties can be examined to identify proposed conservation areas and future development areas.

Two land use questions to address as you plan your project are:

- How have changes in land uses, roads, ditches, and other human constructed features affected water quality, surface water runoff, and drainage/ponding patterns?
- How will these changes in land use, and the presence of roads, buildings, and other human constructed features affect your ability to restore, create, or enhance a wetland?

For more information on watershed features such as wetlands, check the data available on your watershed at the EPA website, <http://www.epa.gov/surf>. For another information source, check the USGS 7.5 minute quadrangle maps for your area; these maps have many relevant landscape features. Also, National Wetlands Inventory (NWI) maps from the FWS for your region will show the location of some (but not all) of the wetlands. Visit their web site at <http://www.nwi.fws.gov/>.

Choosing the Project Site

Some people decide to do a wetland restoration project with a site already in mind--one they own or have a special interest in--but, for many people, site selection is part of the planning process. All restoration, creation, and enhancement projects must be carefully placed in the watershed to meet hydrologic, soil, and biotic requirements. Site selection is a process of setting goals and then looking for sites with characteristics that will support achieving your goals. In the

early stages of planning, you may select one site and then switch to another as your goals are refined. The best approach to site selection is to be flexible. Be willing to adapt your goals if suitable sites aren't readily available.

The first place to start when looking for a project site is a local, regional, or state list of priority wetland restoration sites. By choosing a site from such as list, you will be taking advantage of local wetland restoration expertise. The contacts listed in Appendix R-III, as well as local and state wetland contacts, can help you find out if there is a list of priority restoration sites for your area. Talking to the people who created the list can help you pick the site that best fits your goals and resources.

When there are a number of potential project sites, you will need to evaluate them carefully. Hammer (1992) lists these six factors to consider when choosing a restoration, creation, or enhancement site:

- hydrology;
- topography and geology;
- soils;
- biotics;
- land ownership; and
- agency requirements.

Information on the first four factors may be provided when you conduct the landscape/watershed evaluation described in the previous section. When choosing a project site, specifically consider how to achieve the necessary amount and duration of water for your wetland type. Look for potential locations with the hydrology, topography, and geology typical of the type of wetland you want to restore. Look also for the presence of wetland soils (hydric soils) or drained wetland soils, which indicate places that would be appropriate for wetland restoration. Choosing a site that is close to native species or finding one that already has native species will allow natural colonization of the site. The best sites are likely to be near wetlands similar to your target type.

If you are buying a site, determining the ownership of a potential project site is a critical step. Find out if there are easements, liens, covenants, water-rights issues, or other aspects of the parcel that may restrict its use for your project. Agency requirements also determine the suitability of a site for the intended project. Find out from local, state, and federal agencies what permits or authorizations may be necessary to undertake your project. For more information on this topic, see the section below, "Government and Agency Requirements".

Successful site selection produces locations that will support your wetland project goals. You may need to revise your project goals to reflect the constraints of current conditions if available sites do not meet your original purposes.

Know Your Project Site

Before designing a project, you will want to learn about the past and current conditions of your project site by conducting a site assessment. The goals of a site assessment are to:

- understand former conditions on the site;

- determine whether or not a wetland ever existed on the site; and
- determine what factors resulted in wetland degradation or loss, if a wetland did exist;
- determine the current condition of the site.

This assessment is a more focused version of the landscape evaluation and it may tap some of the same information sources. Examine historical photos (including aerials), historical maps of the area, talk to long-time residents, or hire a wetland professional to determine the locations and types of former wetlands. Past conditions can provide valuable information on impacts to the site that may affect restoration outcomes. For example, if the site history reveals that the area was once a dumping ground for potentially toxic materials, you should contact experts on toxic substances to determine how to proceed. A range of toxic materials can occur in polluted sites, and while some pollutants may be serious problems, others may not. Expert advice is essential for determining whether a polluted site is suitable for your project or whether you should seek another project location.

You will also need to characterize the *current* conditions of the restoration, creation or enhancement site. Information on the site's current hydrology, soils, and vegetation will help you understand the site's potential to become a wetland. Visual inspection of the site and the sources listed in Table 1 can provide qualitative (general) information on the following characteristics:

- topography;
- evidence of erosion;
- evidence of drainage and water movement patterns;
- major vegetation types;
- human structures and land use; and
- adjacent land uses.

In addition to qualitative information, collecting site-specific, quantitative (numerical) data is often necessary to determine the causes and cures for wetland loss or degradation. Quantitative site measurements may be required to obtain permits or to design the project. Collecting quantitative data typically requires the help of local experts familiar with conducting biological assessments and wetland delineations, and who are knowledgeable about the local natural communities. Several quantitative parameters that are often measured in the field include:

- exact elevations and topography of features;
- levels of soil nutrients, organic matter, and moisture;
- water flow rates and timing;
- location of wetland soils, wetland plants, and wetland hydrology; and
- diversity and cover of native and invasive or non-native plant species.

You also should look for site conditions that could limit the project goals. Modifications to the project design or maintenance plan may be needed to address problems such as:

- herbivores that could decimate new plants (Canada geese, muskrats, etc.);
- proper sun exposure for plantings;
- invasive and non-native species on adjacent lands;
- human uses (of the site and adjacent sites) that are incompatible with restoration;
- local pollutants;
- lack of native species nearby;
- future land uses (in and around the site) that are incompatible with restoration;
- presence of cultural resources; and
- poor water quality or lack of sufficient water.

As noted earlier, watershed conditions play a major role in achieving restoration, creation, or enhancement goals. It is important to realize that isolated sites may have more problems reaching their goals than sites located near or adjacent to comparable wetlands. Isolated habitats are more likely to be affected by negative surrounding land uses, may be more vulnerable to invasion by non-native species, and are more difficult for native plants and animals to colonize. However, some wetland types such as prairie potholes and vernal pools are naturally separated from similar habitats. For these types of wetlands, it is appropriate to restore or create them where they typically occur in the landscape and in numbers typical to the watershed.

Setting Goals and Objectives

As you selected the project site and evaluated its condition, you did so with ideas of what you want to achieve. These **goals**, which are general statements about the desired project results, reflect your motivations for undertaking the project. Do you want to see your site support a diversity of native plant and animal species? Are you interested in improving the water quality in local streams? Do you hope to return the site to a condition you remember from years before? Examples of goals for wetland restoration projects might include “repair damage to seagrass beds from boat traffic” or “restore the original plant species and water cycle to a drained prairie pothole”.

Goals provide an overall framework. The next step is to develop **objectives** that provide specific targets focused on hydrology, soils, topography, and/or biological factors that must be changed on the project site to establish or restore a wetland. For the goal, “restore the natural hydrology and vegetation of a degraded Atlantic coast salt marsh”, the following objectives would be appropriate:

- Restore the natural tidal regime;
- Ensure the mudflat is returned to a level appropriate for vegetation;
- Re-establish the native mature plant community, especially *Spartina* and *Salicornia* species; and
- Limit the presence of non-native or invasive plant species, such as *Phragmites*.

Progress is determined by measuring performance standards or **target criteria** that are linked to each objective. Target criteria often include a numerical end-point and a time line to

reach that end-point. For example, the objective “Limit the presence of non-native or invasive plant species, such as *Phragmites*” might be linked to this target criterion: “Reduce the cover of *Phragmites* and other non-native or invasive species to no more than 50 percent of the site area in 2 years and to less than 10 percent of the site in 5 years”. Such numerical targets are measurable and will allow you to know if the site is progressing toward your goals. Target criteria should: (1) be measurable and objective; (2) be collectable with simple methods that generate comparable data each time they are used; and (3) produce repeatable results. Include incremental targets that reflect how the site is likely to change as it moves from its initial condition toward a mature community.

Box 4 provides information on the target criteria set for the West Eugene Wetlands Project in Oregon. This project also illustrates another important point: even if you have a very specific goal, such as providing additional wetland habitat for a rare species, be sure that you focus not just on that one wetland function, but plan to restore as much of the wetland system as possible.

Here are other examples of target criteria:

- If your goal is to restore a seagrass bed, then one objective might be to re-establish native eelgrass. A target criterion for that objective could be to “establish eelgrass plants covering 60 percent of the original area at the end of 3 years”.
- If your goal is to restore a seasonal prairie pothole by re-establishing its natural hydrology, then one target criterion might be to “establish water depths between 1 and 2 feet on 75 percent of the site for the period of the year necessary to support native vegetation”.

BOX 4: West Eugene Wetlands Project Targets Rare Species Habitat

The Lane-Metro Youth Corps of Eugene, Oregon undertook a 9-month wetland restoration project in the West Eugene Greenway, which is managed by the Army Corps of Engineers. The goal of the project was to complete work in endangered and threatened species habitat that would lead to natural re-colonization by the native species. The specific measurable target criteria to be achieved in nine-months included:

- Enhance and restore 5 acres of habitat to provide for the survival and reproduction of Bradshaw’s lomatium and Willamette Valley daisies.
- Collect seeds from 40 acres of native wetlands.
- Construct 11 accessory water channels to enhance site hydrology to support rare daisies.
- Plant native species along 5000 feet of levees to provide a diverse native plant community.

Using Reference Sites

How do restoration specialists determine what kind of hydrology, soil conditions, or specific organisms to establish at a project site? A standard method for setting restoration targets is to base them on the conditions of the wetland that existed on the site before it was altered. If hydrology, soil, and biotic data on the original, pre-damaged condition of the wetland are complete enough, this information can be used to set standards for partially or completely re-establishing the original conditions. Information collected from aerial photos and historical maps may show the former extent of vegetation and/or hydrology. Data from sources such as local water districts, universities, and citizens, may also provide the detail needed.

However, in most cases, there is not enough detailed background information on plant species and cover, animal species and abundance, soil conditions, or hydrology to set target criteria. Because historical information is often missing, most restorationists depend on local “**reference sites**,” which are sites that represent the least disturbed wetlands of the target type in the area. The ecological conditions at reference sites are usually indicative of the natural communities that can be supported under current conditions. Even if we wanted to restore to a “pristine” ecosystem such as the Europeans first saw when they arrived in North America, changes to land uses, water sources, or other aspects of the surrounding landscape in the last 300 years usually make it difficult or impossible to restore a wetland to its original ecological condition (see Box 5). Reference sites provide insight into what is possible now.

BOX 5: Restoration in “The Meadowlands” of Northern New Jersey

A good example of altered regional hydrology and its effect on wetland restoration exists in northern New Jersey in “The Meadowlands”. In colonial times, this area was an Atlantic white cedar swamp, but today the cedars are gone, replaced by fill, roads, buildings, some brackish marsh, and a tall reed known as *Phragmites*. There are numerous wetland restoration projects in The Meadowlands, but none of them are attempting to restore a white cedar swamp. In addition to all the other changes, a dam on the Hackensack River has made the area too salty for cedars. Instead, wetland restoration efforts are focusing on establishing brackish water marsh, which is much more appropriate given the current regional ecological and hydrological conditions.

To collect reference site data, examine nearby unaltered wetlands (or the least altered) that are in the same landscape position as your site (e.g., along a river, in an isolated depression) and appear to be similar to the original condition of the degraded wetland, if known. You may have already collected some information on similar wetlands when you were learning about the local watershed. Try to identify *several* reference wetlands, because wetlands of the same type can vary considerably in their characteristics. Looking at multiple wetlands of the type you hope to establish can help you understand the natural range of variation of the wetland type.

Restorationists also look for data on different phases of recovery to understand how the system will change over time. Some states are currently developing sets of data from reference wetlands. Contact your state water quality agency or department of natural resources to find out if your state is gathering information on reference wetlands. The wetlands division of your regional EPA office may also have information on reference sites. Look also for other restoration, creation, or enhancement projects and talk to the people responsible about how well the project is progressing toward its goals. Understanding how other restoration projects are developing can help you determine whether your goals are appropriate. Looking at other restoration projects is particularly important when you are restoring a type of wetland that develops slowly, such as a forested wetland.

You should collect basic information on the hydrology, soils, and plant community from the reference sites. General information can be collected from visual inspection of the sites and from the sources you consulted for general information on your project site. Reports and published literature may also be a source of general information on reference sites. The Community Profiles series published by the FWS provide basic information on a range of wetland types (see Resource Appendix R-I). Professional restorationists often collect specific, quantitative measurements on the characteristics of the reference sites. These characteristics are the same as those used to quantify conditions on the project site.

When using data from reference sites to set target criteria, remember that ecological systems are not static, so target criteria should include an acceptable range of natural variation. Also plan for typical disturbance regimes, such as 2-year to 100-year flood conditions. While natural disturbance regimes are essential to the long-term health of ecosystems, many a project has been damaged or lost soon after completion because planners did not consider the flood potential or natural disturbance regime of their site.

The following is a list of questions to ask your technical advisors and to keep in mind as you plan your wetland project:

Ask about Hydrology:

- Where can regional baseline hydrologic data, including typical and extreme flood events and their potential be found?
- What are the current hydrologic characteristics of the restoration site?
- What are the original hydrologic characteristics at the restoration site (if known)?
- What parameters should be measured at the restoration and reference sites?
- What has caused changes to the hydrologic characteristics of the site (what removed the water or prevents it from entering your site)?
- Where can reference sites for this wetland type be found in the watershed or nearby?
- Are there potential effects on downstream areas of changing the hydrologic characteristics of your site?
- What is the relationship between the elevation of the land surface and primary water sources (surface and ground water) for the wetland?

- What changes need to be made to restore hydrology and the correct relationship between soil and water levels?
- What design elements should be included to restore the typical hydrological regime and allow for extreme events?
- What soft engineering or bioengineering methods are available to rectify the problems?
- What factors might constrain restoring full hydrological functioning?
- What are likely reasons that the site might fail to reach its hydrological goals?
- What potential remediation or correction measures are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Ask about Water Quality:

- Are there indications of pollution? What are the likely sources?
- What water quality tests are necessary?
- What are the best methods for testing water quality (field kits, lab testing)?
- What methods are available for fixing pollution problems?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Soils and Substrates:

- Where can baseline information about local soils be found?
- Where can reference wetlands be found in the watershed or nearby watersheds?
- What are the typical characteristics of substrates in the wetland of interest? Levels of organic matter, nutrients, soil moisture? Particle sizes and soil structure?
- Are there impervious soil layers contributing to the wetland dynamics?
- What soil parameters should be sampled to characterize the site?
- What are typical substrate elevations and microtopographic features of this wetland type (including channels, islands and mounding)?
- If toxic soils are found, how can they be removed or remediated?
- What methods are available to bring the soil conditions and substrate elevation in line with observations from relatively undisturbed wetlands?
- What bioengineering or soft engineering implementation methods are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What soil and elevation parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Plant Communities:

- What native plant species are found in pioneer and mature stages of the target wetland type? What are the dominant and rare species?
- What special status, threatened or endangered species are found in the target wetland type?
- What natural disturbances are typical of this wetland type?
- On the potential restoration site, what plant species are present, including special status and listed species, non-native invasives, and species native to the target wetland?
- What soil and hydrological conditions on the potential restoration site would constrain establishing the native community? How should these conditions be changed?
- How should the site be prepared (adding soil amendments, removing non-natives, etc.) for establishing native plants?
- What methods are available for eliminating the most damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what methods should be used to establish native plants?
- What are the threats to newly established plants (herbivores, flooding, intense sun, etc.) and how should they be combated?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What plant and plant community parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Animal Communities:

- What native animal species are found in pioneer and mature stages of the target wetland type? What are the dominant and rare species?
- What special status, threatened or endangered animal species are found in the target wetland type?
- What natural disturbances affect animal species in this wetland type?
- On the potential restoration site, what animal species are present, including special status and listed species, non-native invasives, and species native to the target wetland?
- What soil, hydrological and plant community conditions on the potential restoration site would constrain establishing the native community? How should these conditions be changed?
- What habitat conditions will attract the typical animal species and what specific habitat features can be added to attract specific valuable and/or rare species?
- What methods are available for eliminating the damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what can be done?
- What are the threats to newly established animal populations on the site (predators, flooding, pollution, human impacts, etc.) and how should they be managed?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?

- What parameters should be monitored? How often should they be monitored and for how long?

Refine Your Goals and Objectives

The initial goals and objectives for any project may change based on the ecological data collected about the landscape, current and past conditions on the potential restoration site, and the ecology of reference sites. In addition, non-ecological factors such as agency requirements and socioeconomic factors (financial resources, available labor, concerns of adjacent landowners) may alter what you can achieve. Therefore, you may need to revise your goals after considering the following factors.

Government and Agency Requirements. Discuss your project goals with agencies that regulate and manage natural resources. If you have asked these agencies for information or help with an earlier planning stage, you may already be aware of any regulatory requirements relevant to your project. Do not assume that wetland restoration, creation, or enhancement projects are exempt from needing a permit or other authorization--some are, but many are not. For complete information you should call the appropriate federal, state, or local regulatory agencies. If you want to work in a former or current wetland, you may need a permit for your project. Begin with your local district of the Corps. This agency regulates discharges of dredged or fill material to wetlands under Section 404 of the Clean Water Act. Talk to the EPA for other applicable Clean Water Act regulations. If your site is on agricultural land, you may need to talk to the NRCS. Your project also may be subject to federal and state regulations that protect certain kinds of fish and wildlife. States often have "Natural Heritage" or rare species programs that can tell you whether there are plants and animals protected by state or federal regulations on or near your site. Alternatively, you can contact state fish and wildlife agencies and/or local offices of the FWS and NMFS for information. See Resource Appendix R-II for contact information. In addition, you should talk to your city and county planning offices about local requirements or permits for your project.

Be sure to avoid or minimize adverse environmental impacts that may result from wetland project construction activities. For example, earth moving, which can be a part of more complex projects, can cause erosion, increases in particulate matter in the air, and potential disturbance to locally nesting bird species. Avoid impacts by following the requirements of regulating agencies and by implementing the Best Management Practices (BMPs) recommended by the agencies and local municipalities. BMPs to limit erosion may include using silt fences and hay bales to capture silt, avoiding work during rainy periods, and/or capturing runoff in a holding pond.

Socioeconomic Factors. For many projects, restoration potential is restricted by societal factors. Some of these include availability of funds, volunteer resources, local landowner concerns, community support, and legal issues (such as water rights). The relevant societal issues must be considered in your project design and implementation, with the hope that someday in the future some of the limitations to a more complete restoration may be removed.

A major limiting factor is, of course, money. Some projects are relatively inexpensive, but others can be major financial undertakings. Typically, the more engineering that is needed, the more expensive your project will be. To keep costs down, try to tap the expertise of local agencies, universities, and non-profit or community groups. While less common, sometimes local consultants will do work for no charge or for reduced fees. For labor-intensive stages, enlist the help of interested, trainable volunteers. Local non-profit and community groups are great sources of free labor. Local corporations may also have eager community service groups. Don't overlook schools, boy and girl scout troops, and "at-risk" youth groups. Restoration projects offer great outdoor experiences for children and teenagers.

To finance other parts of your project, begin with the list of funding sources in Resource Appendix R-II. Other sources of money or information on funding are:

- local cities or counties;
- state programs, especially through parks and recreation, wildlife or other resource agencies; and
- local corporations, some of which have philanthropy programs for local projects.

Other potential constraints on your project may arise from adjacent landowners and/or a lack of community support. Local communities should be involved if your project may result in controversial effects on public lands. Neighbors may feel that your project could damage their property through potential flooding or other effects. Ask your local experts and agencies if there appear to be any potential community or adjacent landowner issues. See Box 6 for information on an enhancement project that factored in these types of challenges.

BOX 6: Wetland Enhancement in Marshy Hope Creek, Maryland

On Maryland's eastern shore, Marshy Hope Creek winds its way to the Chesapeake Bay. Along most of its reaches it is a meandering stream with lush riparian vegetation. However, where it flows through the town of Fredericksburg, the Creek was straightened and channelized with levees. Much of the vegetation was removed and the original floodplain had been filled. The levees containing the modified portion of the Creek prevented flooding of adjacent properties and local landowners did not want these embankments to be removed. The Maryland Department of Natural Resources (DNR) worked with the town to develop a plan that enhanced the Creek's ecological values while leaving the levees in place. DNR removed fill from the floodplain and created channels through the levee that allowed river water to flow to newly sculpted depressions on the floodplain. The channels also connected the river with existing deep ponds adjacent to the floodplain that were remnants of former mining operations. Soil excavated from the floodplain was used to fill part of the mining ponds to create shallow water habitat for fish. Native vegetation recolonized the floodplain and fish quickly began to use the channels and ponds. Although total restoration was not possible, enhancing the conditions adjacent to Marshy Hope Creek increased overall wetland values of the area.

Choose the Simple Approach

You now know what your site conditions are like and what you want to achieve. What, then, will need to be done for your site to meet its restoration, creation, or enhancement goals? This question links goals with implementation. Methods for implementing projects are very diverse and should be developed with as much ecological, hydrologic, and/or soils expertise as you can muster. In general, the best approach is to use the simplest methods possible, because the more complex a wetland project is, the more chance there is that something could go wrong. Implementation should be achieved through the least destructive means and the most ecologically sound solutions. Passive methods should be considered before more active interventions.

If natural processes cannot be initiated with passive methods, then implementation should focus on bioengineering or **soft engineering** solutions over traditional **hard engineering** solutions. Soft or bioengineering methods are based on working with natural processes. This approach is an alternative to the traditional, hard engineering solutions that often replace ecosystem functions with human-designed structures. For example, hard engineering solutions to controlling erosion along a stream bank such as rip rap or cementing the stream banks destroy natural wetland processes. Soft engineering uses physical solutions that reinstate ecological processes and allow the system to become as self-sustaining as possible. In addition to being ecologically preferable, bioengineering methods are often more economical than traditional techniques. Some researchers have found that hard engineering for erosion control can cost up to four times as much as soft engineering methods. Examples of soft engineering solutions to stream bank erosion include:

- planting native vegetation, especially fast growing species such as willows;
- shoring the banks with logs that will decompose in time; or
- stabilizing the bank with “geotextile materials” that do not decompose, but are covered with soil and allow root growth through the material.

Table 2 contains some of the most common and obvious examples of wetland damage and typical corrective measures. The table also lists some cautions. If the damage is severe or has been present for a long time, reversing the damage may not be as simple as it initially seemed. Some of these corrective measures are also applicable to implementing enhancement or creation projects. Technical Appendix T-III contains additional information on typical measures for restoring, creating, or enhancing wetlands.

Table 2. Common Wetland Problems and Corrective Methods

Wetland Damage	Reason for Damage	Suggested Correction	Considerations
<i>Hydrology</i>			
Water Quality Impairment	Excess sediment or nutrients in runoff from adjacent area	Work to change local land use practices; install vegetated buffers/swales/constructed treatment wetlands; install sediment traps.	Sediment traps will need periodic cleaning; an expert may be needed to design buffers and swales.
Water Quality Impairment	Excess sediments from eroding slopes	Stabilize slopes with vegetation/biodegradable structures.	Bioengineering is preferred; some structures may be needed; many corrective methods exist.
Altered Hydrology (drained)	Ditching or tile drains	Fill or plug ditches or drains; break tiles.	Organic soil may have decomposed so that the elevation of the site is lower than it used to be.
Altered Hydrology (constrained)	Road crossing with undersized culvert	Replace with properly sized culvert or with a bridge.	Hydrologic expert needed to correct this; obtain transportation department permits.
Altered Hydrology (drained)	Former wetland diked off from its water sources	Remove/breach dikes or install water control structures.	Substrate elevation may not be correct for vegetation; add soil or control water level with low maintenance structures.

Wetland Damage	Reason for Damage	Suggested Correction	Considerations
<i>Soils</i>			
Raised Elevation	Soil dumping or fill	Remove material.	Fill may have compressed soil to lower than initial elevation; take steps to avoid erosion.
Subsidence	Soil removal; oxidation of organics; groundwater removal	Add fill; allow natural sedimentation.	Fill must support target wetland; test fill for toxic compounds.
Toxic Soils	By-product of on-site or off-site industrial process; dumping; leaching and concentration of natural compounds.	Treatment systems or methods appropriate to the soil / pollutants; remove material; cover with appropriate soil.	Work with experts to choose treatment methods that cause least amount of indirect damage; choose a different site to avoid serious toxin problems.
<i>Biota</i>			
Loss of Biodiversity	Change in original habitat	Restore native plant and animal community using natural processes.	Allow species to colonize naturally; import species as appropriate.
Loss of Native Plant Species	Invasive and/or non-native plants; change in hydrology; change in land use	Remove invasive, non-native plants (allow native plants to re-colonize); restore original hydrology.	Pick lowest impact removal method; repeat removal as non-natives re-invade; alter conditions to discourage non-native species.

Prepare for Implementation

After determining what site changes are necessary, prepare to implement the changes by developing project designs such as field protocols or construction plans and specifications. Protocols are written guidelines for field crews on how to undertake the work. They should be as specific as possible, but in easy-to-understand language, especially if volunteers will be doing the work. Even with protocols, volunteers will need direction in the field.

Most projects will need some level of documentation to direct implementation; more complex projects will probably need construction plans. Good designs include at least these elements:

- specifications/diagrams for all installation/construction features;
- descriptions of site preparation needed;
- descriptions of how to install features, such as plants, etc.;
- plans to prevent construction impacts, such as erosion;
- lists of plant species, numbers of each to be planted, and planting locations;
- plans for site maintenance; and
- monitoring features, such as groundwater wells, staff gauges, or boardwalks.

The design of restoration, creation, or enhancement projects can be highly technical and may require hydrologists, ecologists, geotechnical experts, engineers, and/or landscape architects. Construction documents are usually prepared by engineers for use by contractors in the field for constructing a project. If construction documents are necessary, take the time to find engineering and construction firms that are flexible and willing to undertake non-traditional designs and soft engineering methods. Try to find firms that have done wetland restoration work in the past. Talk to their former clients to see what their work was like. Be sure your ecological advisors work with the engineers to produce plans that accurately reflect the methods you want used for the project. During construction, have the work inspected by your ecological experts to be sure that the plans are being followed accurately.

Publicize Your Project

After talking with your neighbors and the appropriate agencies, and after developing feasible goals and objectives, consider writing a small article for a local newsletter or newspaper describing your project and its benefits. Publicity at the end of the planning phase lets people know about the work and may turn up local issues you had not considered. More often, publicity builds public support and can help you find volunteers to help you install and monitor the project.

BOX 7: Steps in the Planning Process

- Establish goals.
- Collect past and present information on the local watershed.
- Choose a project site.
- Collect past and present information on the project site.
- Collect data on reference sites.
- Develop objectives and target criteria based on watershed, project site, and reference site information.
- Talk to the agencies about appropriate regulations. Talk to adjacent landowners and identify important social or economic factors that could affect the restoration.
- Refine goals and objectives.
- Decide on methods for implementing changes designed to rectify damage and meet planning goals and objectives.
- Prepare designs, such as protocols or construction documents, to direct implementation.
- Publicize your project.

PART 5. IMPLEMENTATION

Stages of Implementation

Implementation is the physical process of actually doing the restoration, creation, or enhancement project according to the design developed in the planning stage. This phase of the restoration process is popular with volunteers and it is the most visible phase to the public. Implementation may require a series of steps depending on the wetland type, your project goals and objectives, and the extent of the degradation. When the project is being installed, be sure to work with your technical team to determine whether the project is being constructed properly. Steps in implementation typically include site preparation, plant preparation, installation, maintenance, and adaptive management.

Site Preparation. During site preparation, the project site is altered either to allow natural processes to operate or to prepare it for additional human intervention. For many projects, site preparation may be the only work needed. Although passive methods are typically implemented in the site preparation phase, both passive and active approaches may be employed to remove sources of degradation and set the stage for ecological processes to take over. For seriously damaged sites, as well as for creation and enhancement projects, passive methods will not achieve the goals and active methods will be needed. Common activities in this stage are:

- removing non-native species (See Box 6);
- removing piles of soil, debris and trash;
- amending soil with nutrients or other enhancements;
- removing polluted soils;
- bringing in appropriate soils or substrates;
- plugging or removing drains;
- fencing out cattle or other herbivores;
- breaching levees; and
- mowing or burning the site to reinstate the natural disturbance regime.

Plant Preparation. For many restoration projects a passive approach can be used to re-establish native wetland vegetation. Native seed banks are present in most wetlands. As long as the soils have not been removed or filled over, native seeds will germinate and grow when suitable conditions have been restored. There also may be local sources of plants that can drive natural re-colonization. However, for many other projects, indigenous species must be brought to the site. If native plants must be grown for the site, plant preparation should begin during or before site preparation. Growing the number of plants needed may take 6 months to a year.

Always use native species and cuttings or seeds from local plants. Locally-adapted seeds and plants will have a better chance of surviving the conditions at your site than plants or seeds of the same species that come from another area. When collecting native plant material, take care not to damage the collection site and always check with the property owner (public or private) before collecting plant material. Plant preparation includes:

- collecting seeds;
- propagating plants;
- collecting cuttings; and
- collecting plugs (newly-grown whole plants with soil).

There are innumerable methods to collect and treat plants and seeds. Find out from local botanists, plant experts, or restorationists what methods are best for the species you need. Native plant nurseries and native plant societies may also have expertise with local native species and they may have seeds or plants appropriate for the area. They may also be able to grow particular species that are not available in nurseries.

BOX 8: Controlling Invasive Species--A Tale of Two Wetlands

Invasive species, especially plants, are a tremendous problem in the U.S. They destroy more habitat each year than urban growth and the FWS estimates that 4600 acres of habitat are lost *each day* to invasive species. Consequently, removing these invaders is a major component of restoration work. Control methods and success rates vary widely, as the following examples show.

In Fairfield, Connecticut, impounded salt marshes that were once tidal were overrun by *Phragmites*, a tall invasive wetland plant. *Phragmites* had replaced the local plant species and, being prone to burning in the summer, the invader was threatening homes near the marsh. *Phragmites* is intolerant of high salt levels and the City was able to quickly reduce the infestation by installing tidal gates that allowed the return of salt water to the marsh. This project was expensive, but it was very effective.

Not every case is so easy. At the Hayward Regional Shoreline along the San Francisco Bay, an insidious invader has taken root in the tidal salt marsh. *Spartina alterniflora* (smooth cordgrass), a species from the east coast of the U.S., is replacing its close relative, the native *Spartina foliosa*. Smooth cordgrass is a tough customer. It is tolerant of a wider range of conditions than its cousin and it has resisted all efforts to remove it. Biologists have tried digging it up, spraying it with herbicide, and cooking it under black plastic mats. None of these measures have worked well and the plant is spreading. Biologists worry that rare animal species dependent on native cordgrass--species such as the endangered California clapper rail--may not use the east coast cordgrass. The search is on for a biological control agent that will specifically target and destroy *S. alterniflora*.

Installation/Construction. During installation, the project is literally put in the ground. A wide array of activities can occur during this phase including large earth-moving activities, such as grading. Minimize the temporary but destructive impacts that may occur at this stage. Keep grading to a minimum, limit the movement of heavy vehicles to the smallest footprint possible, and use the methods that create the least disturbance possible. Implement appropriate BMPs. Installation/construction may include:

- grading existing soils;
- placing and grading substrate;
- planting plugs, seeds or newly-grown plants;
- installing plant protections (tubes, screens, etc.);
- placing irrigation systems;
- constructing water control structures;
- installing bank/edge stabilization structures;

- building habitat islands; and
- constructing and placing habitat structures.

As-Built Documentation. After the project is installed, conduct an “as-built” assessment, which is a detailed description of the site conditions immediately after the installation is completed. If you and your volunteers installed the site, document whether everything was installed as expected. If the work was done by a contractor, the as-built assessment should be conducted by a site inspector who is not employed by the contractor to document whether the project plans and specifications were followed by the contractor. This also ensures that the site complies with any regulatory (e.g., permit) requirements.

It is likely that there will be some deviations from the site plan caused by human error or unanticipated characteristics of the site (e.g., a hidden spring in a corner of the site). Any deviations should be documented and discussed with your technical team to determine whether they need to be corrected to ensure that the project meets its goals. If the installed project deviates in important ways from the plans, have the construction firm correct the problem--but only if the benefits of corrections outweigh the impacts from further disturbance. If corrections are needed, they should be made as soon as possible. The as-built assessment also provides a “baseline”, or starting point, for measuring change during subsequent monitoring.

Maintenance. Implementation does not end with installation. Maintaining the site in good ecological condition is a critical part of implementing a project. Many factors can conspire to undo the hard work you put into the previous stages. Maintenance may require:

- controlling non-native and invasive species;
- controlling herbivores;
- repairing structures;
- maintaining staff gauges and other equipment;
- replacing plants;
- mowing, burning, and/or other activity reinstating or mimicking the natural disturbance regime;
- reducing or preventing human intrusion; and
- controlling local pollutants.

Working with Volunteers

The implementation and monitoring phases are great times to involve volunteers and there are many good reasons to include volunteers in your project. Volunteers can help reduce the costs of implementation, provide community support, and bring a social dimension to the work. Working with volunteers may be one of the most rewarding aspects of your project. Among the volunteers, you may find experts, new friends, and dedicated helpers. Some helpers may be inspired to undertake a similar project of their own and you may find people who will want to continue stewarding your site by helping you with maintenance and monitoring.

Look for volunteers through non-profit environmental groups, schools, public community service groups, and private service groups organized by local corporations. If you do decide to use volunteers, you will enjoy the vitality that they bring to the project. You will also have to carefully train and monitor those enthusiastic helpers. The more complex the task the more training volunteers will need. Generally, it is best to have volunteers do one or two simple but time-consuming tasks. Keep things interesting by rotating people among different tasks. Carefully observe volunteers to be sure they are following protocols. Encourage and reward your helpers' hard work.

Discuss your project with the volunteer coordinator for a local non-profit group to determine any issues that may arise from using volunteers. While volunteers can be great additions to a project, weigh the benefits against these potential complications:

- the time and effort required for training;
- the potential need for compensation;
- oversight of volunteers' work; and
- potential liability issues.

Publicize Your Project

The implementation phase is a great time to get the local media (especially newspapers and television) interested in your project. People working outside on restoration projects provide great photo opportunities and these action shots are often popular with the local press. Find out if any of your volunteers have media contacts or call local TV and newspaper science, outdoors, and current events reporters. If reporters do cover your project, be sure that they come to the site on a day when the volunteers are well-organized and are doing active, positive work. For example, plan media events on days when volunteers are planting seedlings. You or another supervisor must be on site and the volunteers must be informed that the press will be there. Prepare what you or your spokesperson will say to the reporters. Tell them a little about the history of the project and always highlight the positive environmental and community benefits of the project.

BOX 9: Summary of Implementation Stages

- Prepare the site by making changes that allow natural processes to occur.
- Prepare plants by collecting materials from local stocks.
- Install the plants, structures, and major features of the project.
- Maintain the site by regular repair of structures, removal of non-native plants, and other typical maintenance activities.
- Involve volunteers to keep costs down and develop community support.
- Publicize your project.

PART 6. MONITORING

What is Monitoring?

Monitoring is systematic data collection that provides information on progress towards target criteria or performance standards which, when met, indicate that established ecological goals have been reached. Thus, monitoring provides data on whether a site is developing in a way that will achieve the project goals.

A common misconception about wetland restoration, creation, and enhancement is that once a project is implemented, nature will just do the rest. In reality, many wetland projects need mid-course corrective actions such as re-planting seedlings that were washed away by a storm, digging more channels to get water to remote parts of the site, or plugging ditches missed during the initial site survey. Monitoring tells you if you need to make these corrections. Monitoring can also give information on routine maintenance that may be necessary to keep the site functioning well. Broken sprinkler heads, non-native weed growth, and holes in fences are just a few of the routine maintenance items that are easily observed during monitoring.

What Should I Monitor?

Monitoring consists of measuring a number of wetland attributes or parameters at regular intervals to record the changes in the wetland. The parameters to be measured at any particular site are based on the project objectives and target criteria. An array of parameters is usually measured to assess hydrology, soils, and biological conditions on the site. After the project is completed, initial site conditions (including as-built conditions) are documented to provide baseline information against which changes to the site can be evaluated. Typical parameters measured to evaluate wetland functions are listed in Technical Appendix T-IV.

How Should I Monitor?

Two basic approaches to monitoring are to collect qualitative (observational and general) information and to collect quantitative (numerical and specific) data. Qualitative methods can be used in conjunction with quantitative measures. Qualitative methods may dominate monitoring in the first few years of a site's development when wetland hydrology, hydric soils, and plants and animals are becoming established. During this period, additional disturbance to the site should be avoided (unless necessary to correct problems), which means that non-intrusive qualitative monitoring of the most important wetland characteristics may be more appropriate than the intensive sampling typically required for quantitative monitoring. Qualitative methods typically do not provide enough information to accurately determine how close the site conditions are to target criteria, but they do give a general view of whether change is occurring. Some typical methods for gathering qualitative information for different parameters are given in Table 3.

Quantitative methods are used to provide detailed information about how the wetland is developing with respect to target criteria and can also provide information important to long-term

wetland research. Specific quantitative methods to measure certain ecological structures or processes may be needed if basic monitoring indicates there is a problem and information is needed to develop corrective actions.

A wide range of methods exist for collecting numerical data. With your technical advisors, develop the most appropriate methods for your project. Talk to local wetland experts and get their advice on what is needed for adequate monitoring and whether there are special circumstances (*e.g.*, rocky soils that make it difficult to install wells) or opportunities (such as a nearby school looking for a science project) that will affect how you monitor your wetland. Examples of some quantitative methods include:

- randomly established transects across the site to record plant species and cover by species;
- setting traps for small mammals at randomized locations to determine species diversity and abundance;
- collecting a representative sample of sediment cores to test for organic matter and other soil characteristics;
- surveying surface elevations at permanent transects once a year;
- measuring water level changes with an automatic water level gauge; and
- collecting and testing water samples periodically to evaluate changes in water quality.

Table 3. Examples of Qualitative Monitoring Methods

Method	Information Provided	Comments
Aerial photographs	General hydrology; evidence of channelization and general substrate levels; extent of site covered by plants	Photograph at least yearly at the same season and at most useful water level.
Ground-level photographs	Identification of some plant species; general level of plant growth; general substrate levels; general water levels; some bird species	Take photos from permanent photopoints; photograph regularly and multiple times (at least yearly) during the same season when water levels are most useful to record change over time.

Method	Information Provided	Comments
General observations	Water clarity and scum; presence of trash; evidence of human use; bird species present; vegetation condition (stressed, blooming, healthy), presence of invasive plants; evidence of erosion, integrity of structures	Check as often as once per month, and at least once a quarter; record on a standardized form; look for maintenance needed.

Quantitative monitoring is often carried out by experts in hydrology, soils, or biota. However, volunteers may be used to collect numerical data if they are supervised by an advisor who knows the protocols for data collection. With the right training and supervision, wetland quality can be monitored by citizens to provide useful information. Quantitative methods can be expensive and time consuming, but they do provide the most accurate information on site changes. See Technical Appendix T-IV for common quantitative methods and qualitative methods used to monitor ecological attributes. Box 10 gives an example of a monitoring plan that measures a range of parameters.

Even if you have very limited resources, monitor by observing your site and documenting the changes using basic qualitative methods. Take photographs of the site and write down general observations such as how wet the site is and for how long, what the soils are like, what kinds of plants are growing on the site, and what kinds of animals you see or hear. Repeat the photographs (from the same vantage point) and the written descriptions as often as you can. The result will be a chronicle of your wetland project for yourself, future owners of the land, and others interested in your site.

BOX 10: Monitoring in Mountain View, California

The Stevens Creek Tidal Marsh restoration project in the City of Mountain View is a compensatory mitigation site with the primary goal of providing vegetated tidal marsh habitat for rare species such as the salt marsh harvest mouse. The site began as a deep pit with ponded water. Project objectives included restoring tidal influence, building up the mudflat, and establishing native tidal salt marsh vegetation. Target criteria included:

- Re-establish tidal influence.
- Within 3 years, develop mudflat on 50 percent of the site at an elevation available to vegetation.
- Restore native salt marsh vegetation on 50 percent of the site within 5 years.

To assess progress, the City monitored the following parameters once a year:

- Amount of tidal exchange: measurements were taken by an automatic tide gauge and interpreted by a hydrologist.
- Elevation of the mudflat: measurements were taken by a qualified surveyor.
- Amount of vegetation on the mudflat: measurements were taken on the ground using transects and taken from aerial photographs, then interpreted by an ecologist.
- Extent of channel formation: measurements were taken from aerial photographs and interpreted by a hydrologist.

These quantitative methods were supplemented by qualitative observations on tidal flow, non-native species invasion, bird use, and human use.

How Often Should I Monitor?

How often and when a particular attribute should be monitored depends on many factors including the attribute's natural variability, the rate of change of the site, and the goals of the project. Most characteristics should be monitored at least annually. Vegetation should be monitored during the growing season (monitoring in both the early and late growing season will make it easier to identify all plants), and animals should be monitored during breeding, nesting, and/or migration seasons. Depending on your project goals, you might want to monitor hydrology during both high and low water periods. Once the site has stabilized, some characteristics such as wetland size may be monitored less frequently, unless there are signs of change.

Monitoring on a regular basis is important, and you may need help doing it. Ideally, every stakeholder involved in the wetland project should help with the monitoring so they can see the benefits of their work and continue to support it. Monitoring is a good way to get the local community involved in your wetland project, and it's a great way to give people hands-on

experience in learning how local ecosystems function. Talk to schools, clubs, and other community groups to see if they would be interested in helping you with the monitoring. Have training sessions for volunteer monitors. Many states have active volunteer monitoring groups or programs that monitor lakes and streams. Many are also beginning wetland monitoring projects. Check out the EPA website for information on volunteer monitoring at <http://www.epa.gov/OWOW/wetlands/wqual.html#Volunteer>.

How Long Should I Monitor?

Like most ecosystems, wetlands change over many years. This is especially true for restored, created, or enhanced wetlands that may take decades to reach a condition close to that of a mature, naturally-occurring wetland. Research on wetlands created from dredged material in the Gulf of Mexico suggests that these wetlands are still changing and maturing 20 years after they were created. Consider monitoring to be a long-term activity, not just something you do for the first year or two. At a minimum, a site should be monitored until it appears to be mature and self-sustaining, which can range from several years to decades. Future managers of wetlands will thank you for monitoring for as long as you can. Even after it reaches maturity, your wetland will be a dynamic system that varies over time.

What Should I Do With the Monitoring Information?

Monitoring data can be used in several ways. First, qualitative or quantitative monitoring information are essential for determining whether your project goals are being met. Organize, summarize, and graph (if possible) the monitoring data to show how the restoration site is developing. Monitoring information should be compared to the target standards to assess whether the site is developing as planned. If it is not, determine whether remedial measures should be taken or whether the original goals should be reevaluated (see Part 7).

Second, monitoring data can be used to determine whether the target criteria were good measures of the project goals you hoped to achieve. If you were to do this again, would you do anything differently? Third, use long-term monitoring to assist in maintaining structures and managing the site to keep it functioning well. See Part 7 for more on long-term management.

Finally, use your monitoring data to inform others. Provide copies of your findings to your local planning and wetland regulatory authority, and the local offices of the Corps, EPA, FWS, NMFS, or NRCS. Present your work to local groups and ecological societies or at professional meetings of the Society of Wetland Scientists, Society for Ecological Restoration, and others (see Appendices for contact information). Write an article for the local newspaper or a journal, such as *Ecological Restoration*, which publishes reports from landowners, community groups, and restoration practitioners. All too often, years of irreplaceable data are lost if they are not shared, archived, or published. Don't assume no one is interested in your project; every wetland restoration, creation, and enhancement project that is monitored provides wetland scientists and restorationists with additional knowledge about how wetlands function and develop over time. With this additional information, scientists, policy-makers, and landowners

can make better decisions about wetland conservation, including the use of wetland restoration, creation, and enhancement.

BOX 11: Steps in the Monitoring Process

- Select the parameters you will monitor based on the target criteria established in the planning stage. Include observations to assist in site maintenance.
- Develop procedures for qualitative and quantitative monitoring methods.
- Collect data at intervals that will provide information necessary to monitor the progress of the site relative to the target criteria.
- Consider additional site work if monitoring shows that site conditions are not meeting target criteria.
- Continue long-term monitoring and maintenance to ensure that the site continues to provide the maximum ecological value.
- Provide your monitoring data and results to local groups and publish in newsletters.

PART 7. LONG-TERM MANAGEMENT

In addition to providing data on whether a site is developing in a way that will achieve the project goals, monitoring is essential for the long-term management of wetland projects. A wetland is an ecosystem that evolves and changes in response to the surrounding environment. It is not realistic to expect that when the implementation stage is complete, the work is done. Long-term management is often required to keep the site functioning as it was designed to function and to keep human impacts to a minimum. For example, long-term management is often needed to:

- maintain existing structures such as berms, water control structures, or levees;
- maintain a specific desirable plant community by burning, mowing, or otherwise managing the vegetation on a periodic basis;
- address problems such as invasive species or excessive sediment deposition; or
- address unexpected events such as structural failure.

Monitoring provides information on conditions that may be diverging from the project goals. This divergence may be caused by incomplete or inaccurate information when the project was designed, incorrect installation of the project, or unanticipated changes in conditions affecting the site. If your site is not developing as anticipated, there are two basic options: make changes to the site to try to get it “back on track”, or allow the site to continue developing in the new direction. Which option to pick should be decided in consultation with your local experts.

Consider whether current progress at the site might achieve your overall goals in a different way than you originally intended. Also consider whether any deviation from the expected development is within the ecological norms for that wetland type and the region. Since natural systems are variable, sites may diverge from objectives - but this difference may not require significant changes to the site. For example, your site may be developing a native wetland community, but one that is different from what was expected. If this new community is within the norms of the wetland type and the watershed, it may not be necessary to change it.

If, however, your site is growing a crop of invasive or non-native species or otherwise falling far short of restoration objectives, then corrective action is probably necessary. Significant corrections to a site are called **remedial** or **contingency measures**. The process of monitoring conditions and then taking corrective action is called **adaptive management**. Work with local experts or your technical team to determine the source of the problems and the appropriate remedial actions. The remedial measures taken will depend on why the site is diverging from its expected path and what the costs and impacts of the changes would be. Always consider whether changing conditions on the site will be worth the cost of the disturbance that would be incurred. Typical problems with wetland sites include the hydrology not being properly restored, incorrect water-to-substrate elevations, nutrient problems with the soil, and rapid invasions by non-native species. Some typical remedial measures include:

- regrading the site to the correct substrate elevations;
- contouring channels or installing structures to redirect water flow;
- adding to or reworking water control structures or altering structure operations;
- removing invasive plants, planting native species, or installing a cover crop; and
- replanting.

Box 12 - Adaptive Management in Commencement Bay, Washington

The Middle Waterway Shore Restoration project is an attempt to re-establish some of the salt marsh that once covered thousands of acres of Commencement Bay. In a cooperative effort, federal, state, tribal, and private interests planned and implemented a restoration project that included re-grading fill material to intertidal elevations and planting salt marsh plants salvaged from the same area, as well as some provided by a nursery. One year after project implementation, monitoring showed that few of the plants had survived. A review of the planting procedures pointed to a number of possible causes for the low plant survival, including soil that was too sandy, nursery plants that weren't from the local area, and planting during the summer. The goal of the project (increasing the acreage of fringing marsh) could not be achieved without better plant growth, so a decision was made to replace some of the soil and re-plant. The top eighteen inches of the sandy fill was replaced with topsoil. A local nursery collected seeds from plants in the local area and grew them into seedlings, which were planted on the site in the spring. A year after this new planting, salt grass, seaside plantain, seaside arrowgrass, and other species are thriving. Monitoring will continue in case other remedial actions are needed, but for now the project seems to be on the right track.

Long-term management often is needed to compensate for changes in the surrounding landscape. In many cases, the surrounding land use, hydrology, or other features of the local watershed will change over time, possibly affecting your wetland site. Ideally, those changes were at least partially anticipated, and your site was designed to withstand or adapt to their effects. If something unanticipated happens, such as a substantial reduction of the water source or conversion of what had been an adjacent park area to development, you will need to reevaluate how your wetland site fits into the changed landscape, and whether the goals or management of the site will need to change. The overall goal of long-term management is a wetland that provides a maximum amount of wetland function and value within the context of the landscape and that requires a minimum amount of intervention by humans.

Finally, a plan for long-term management is needed to identify who will be responsible for the site and what kinds of activities should or should not occur there. The responsible party may be you, the landowner, or some combination of people. One approach to long-term management of a restoration site is to establish a stewardship program for the site. Local schools, scout groups, or citizen conservation groups may be willing to "adopt" the site and provide the kind of observation, care taking, and even remedial action that would be difficult for one person to provide. The kinds of activities you need to think about are recreational (do you want to allow hikers, campers, bird-watchers, or hunters on the property?) and possibly commercial (does the landowner want to allow grazing or tree-cutting on the property?). The answers to these questions should be included in a long-term management plan.

Long-term legal protection of a wetland site is also an important consideration. Do you want to take steps to ensure the wetland restoration will be permanently protected? One way might be to place a deed restriction on the site or establish a conservation easement. These arrangements should effectively restrict harmful activities that might otherwise jeopardize achieving the goals of the wetland project. When needed, the acquisition and protection of water rights should be secured. One of the best ways to secure long-term protection is to donate or sell the land to a local, state, or federal natural resource agency or a non-profit organization such as a land trust.

PART 8. PUTTING IT ALL TOGETHER

Words to the Wise

While restoration, creation, or enhancement projects can be complex and time-consuming, most restorationists find their projects are very rewarding. As you undertake a project, keep in mind the following points:

- *Be patient.* Restoration is a process, not a product. Restoration is a creative activity and there is no cookbook for it.
- *Talk to many people.* There are many elements and phases to wetland projects and many different views on how to accomplish them. Talk to a range of people to collect as much information as possible and to get different perspectives on the process.
- *Be flexible.* Your ideas and goals may be clear at the outset, but for many reasons it may be best to change some, add some, and throw others out. As you go through the process, be flexible but keep your goals in mind.
- *Take your time.* Try not to rush the process. Get the technical help you need. Get the permits required. Develop a community support base, if necessary.
- *Plan well.* A well-considered and thorough plan will guide you through the project as directly as possible. A good plan will result in reasonable, measurable and ecologically beneficial goals. A good plan will help you get money and help.
- *Let reference sites be your guide.* Reference sites are valuable models of what ecological conditions are achievable.
- *Use low impact implementation methods.* Use soft engineering and passive methods whenever possible. Consider the impact the project construction will have and minimize those impacts.
- *Monitor and manage your site.* Restoration does not end after the plants and structures are installed. All restoration projects must include monitoring to see if goals are being met and to direct the long-term management of the site.
- *Do your best to recover as much of the wetland system as possible.* Restoring, creating or enhancing sites with the greatest ecological functioning possible, so that they are self-sustaining for the long-term, is the highest goal.

A Wetland Restoration/Creation/Enhancement Checklist

Use this checklist to help guide you through the wetland project process.

- ☐ Talk to local wetland experts. Visit local wetland restoration, creation, or enhancement sites as well as relatively undisturbed wetlands.
- ☐ Ask about getting help through programs that support wetland restoration with cost-sharing and technical assistance.
- ☐ Get to know the local landscape and watershed characteristics.
- ☐ Give first priority to restoring degraded wetlands.
- ☐ Set goals. Pick a site that is most appropriate for achieving your goals.
- ☐ Plan your entire project before you start. Include monitoring and long-term management in your planning.
- ☐ Clarify your goals with specific objectives. Quantify the objectives with measurable target criteria.
- ☐ Identify techniques for achieving your objectives.
- ☐ Develop written protocols or construction documents.
- ☐ Discuss your plans with local regulators, wetland experts, and adjacent landowners.
- ☐ Implement your plans. Have someone who understands the project on the site whenever work is occurring.
- ☐ Perform an “as-built” assessment after site work is completed.
- ☐ Involve local volunteer organizations in the project’s implementation, monitoring, and long-term management.
- ☐ Publicize your project.
- ☐ Develop a written monitoring plan. Monitor your project’s development.
- ☐ Send monitoring results to local wetland experts and discuss the results with them.
- ☐ If necessary, make additional changes to the site to keep it on track.
- ☐ Develop a long-term management plan.
- ☐ Investigate protecting the site in perpetuity.

RESOURCE APPENDICES

APPENDIX R-I: BIBLIOGRAPHY

Below is a list of sources of information on wetlands and wetland restoration. It is not a comprehensive list, just a way to introduce you to the wealth of information available.

ONLINE BIBLIOGRAPHIC RESOURCES:

- <http://www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm> - A searchable wetland restoration bibliography with over 3,000 entries, developed by the Northern Prairie Science Center and the Midcontinent Ecological Science Center.
- http://www.wetlands.agro.nl/wetl_publications.html - A 1996 compilation of over 1,000 wetland restoration and creation literature references is available for download from Wetlands International and the Association of State Wetland Managers
- http://www.nwrc.gov/library_catalog.html - National Wetlands Research Center's Library (11,000 documents)

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APPENDIX R-II: FEDERAL FINANCIAL ASSISTANCE

Below is a list of some federal sources of money that may be applicable to wetland restoration projects. Be sure to contact your state environmental agencies for other sources of funding and check with some of the organizations listed in Appendix III for possible nonprofit assistance.

ENVIRONMENTAL PROTECTION AGENCY

Clean Water Act State Revolving Fund

Purpose:	Provides grant funds to states to help them establish state revolving fund (SRF) programs. States, in turn, offer loans and other types of financial assistance from their SRFs to municipalities, individuals, and others for high-priority water quality activities.
Projects:	While traditionally used to build or improve wastewater treatment plants, loans are also used increasingly for: agricultural, rural, and urban runoff control; wetland and estuary improvement projects; wet weather flow control (including stormwater and sewer overflows); alternative treatment technologies
Assistance:	States offer loan rates that are two to four percent below market rates. Some states offer even lower interest rates to small, economically disadvantaged communities.
Eligibility:	Municipalities, individuals, communities, citizen groups, and non-profit organizations, though each state ultimately determines eligibility.
Address:	U.S. EPA, Office of Wastewater Management, 1300 Pennsylvania Avenue, Washington, DC 20460
Phone:	(202) 260-7360 or (202) 260-2268
Facsimile:	(202) 260-1827
E-mail:	srfinfo.group@epa.gov
Web Site:	http://www.epa.gov/OWM

Five-Star Restoration Program

Purpose:	To promote community-based wetland and riparian restoration projects
Projects:	The projects must have strong on-the-ground habitat restoration components that provides long term ecological, educational, and/or socio-economic benefits to the people and their community.
Assistance:	Each project would ideally involve at least five partners, who are expected to contribute funding, land, technical assistance, workforce support or other in-kind services that match EPA's contribution which amounts to about \$10,000 on the average per project.
Eligibility:	Partners may include citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, tribal agencies and local governments.

Address: Five-Star Restoration Program, US EPA, Wetlands Division (4502F), 100 Pennsylvania Ave., N.W., Washington, DC 20460
Phone: (202) 260-8076
Facsimile: (202) 260-2356
E-mail: pai.john@epa.gov
Web Site: <http://www.epa.gov/owow/wetlands/restore/5star/>

Nonpoint Source Implementation Grants (319 Program)

Purpose: To help States, Territories, and Tribes develop and implement programs to prevent and control nonpoint source pollution, such as creating constructed wetlands to clean-up urban runoff and agricultural wastes.

Projects: State, Territories, and Tribes receive grant money (and may then provide funding and assistance to local groups) to support a wide variety of activities, such as technical assistance, financial assistance, technical programs, education, training, technology transfer, demonstration projects (e.g. best management practices), and monitoring specific to nonpoint source implementation.

Assistance: Grants are first awarded to state agencies. Local organizations can then apply for grants through the agencies, but they must provide 40 percent of the total project or program cost as non-federal dollars.

Eligibility: State, local, and tribal governments, nonprofit and local organizations, etc. (check with your state contact)

Address: U.S. EPA, Office of Wetlands, Oceans, and Watersheds, 1300 Pennsylvania Avenue, Washington, DC 20460
Phone: (202) 260-7100
Facsimile: (202) 260-7024
E-mail: ow-general@epa.gov
Web Site: <http://www.epa.gov/owow/NPS>

DEPARTMENT OF AGRICULTURE (USDA)
USDA - Forest Service

Taking Wing

Purpose: To create and enhance partnerships in the management of wetland ecosystems for waterfowl and wetland wildlife, while providing a variety of compatible recreational opportunities on National Forest System lands.

Projects: Focus towards on-the-ground wetland enhancement and restoration, although some projects include assessment and analysis components. Example: restoration of 100 acres in the Columbia River Scenic Area.

Assistance: Funds are allocated to Forest Service units through internal budget process.

Eligibility: Non-federal entities and individuals - projects must be on National Forest System lands or provide benefits to those lands.
Address: Cynthia Ragland, One Waterfowl Way, Memphis, TN 38120
Phone: (901) 758-3722
Facsimile: (901) 758-3850
E-mail: cragland@ducks.org
Web Site: <http://www.fs.fed.us/outdoors/wildlife>

USDA - Farm Service Agency

Conservation Reserve Program

Purpose: To establish long-term resource-conserving covers on eligible cropland to conserve soil, water, and wildlife.
Projects: Voluntary program where landowners receive rental payments or enter into a cost-share restoration agreement, while maintaining private ownership, to plant cover on marginal cropland.
Assistance: Three options: 1) receive annual rental payments of up to \$50,000/year; 2) receive payment of up to 50% of cost to establish cover; 3) receive payment of up to 25% of cost for wetland hydrology restoration. Contracts are typically 10-15 years in length.
Eligibility: Individuals, states, local governments, tribes, or any other entity who owns private land for at least 1 year that is: either cropland planted with a crop in 2 of the last 5 crop years or marginal cropland that is enrolled in the Water Bank program or suitable to be used as a riparian buffer. Also, the land must be either highly erodible land, a cropped wetland, be devoted to highly beneficial environmental practices, subject to scour erosion, located in a CRP priority area, or be a cropland associated with or surrounding non-cropped wetlands.
Address: Contact your local or state Farm Service Agency office (see “<http://www.fsa.usda.gov/dapdf/>”); otherwise: Department of Agriculture, Farm Service Agency, Conservation Reserve Program Specialist, Stop 0513, Washington, D.C. 20250-0513
Phone: (202) 720-6221
Facsimile: n/a
E-mail: info@fsa.usda.gov
Web Site: <http://www.fsa.usda.gov/pas/publications/facts/pubfacts.htm>

USDA - Natural Resources Conservation Service

Conservation Technical Assistance

Purpose: To assist land-users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems

Projects: Projects that reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands

Assistance: Technical assistance available to land users who voluntarily applying conservation and to those who must comply with local or state laws and regulations, such as the wetland (Swampbuster) provisions of the 1985 Food Security Act and the wetlands requirements of Section 404 of the Clean Water Act.

Eligibility: Individual landusers, communities, conservation districts, and other units of State and local government and Federal agencies

Address: Contact your local or state National Resources Conservation Service office (see “<http://www.nrcs.usda.gov/perdir.html>”); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-4527

Facsimile: n/a

E-mail: n/a

Web Site: <http://www.nrcs.usda.gov/NRCSProg.html>

Emergency Watershed Protection Program

Purpose: To protect lives and property threatened by natural disasters such as floods, hurricanes, tornados, and wildfires

Projects: Examples: Clearing debris from clogged waterways, restoring vegetation, stabilizing river banks, restoring wetland flood retainers

Assistance: Funds cover up to 75% of costs to restore the natural function of a watershed. Another option is to offer land for a floodplain easement that would permanently restore the hydrology of the natural floodplain as an alternative to traditional attempts to restore damaged levees, lands, and structures. Funds can cover up to 100% of the agricultural value of the land, costs associated with environmental measures taken, and costs associated with establishing the easement. A sponsor must assist you in applying for assistance. Sponsors can be any legal subdivision of state, local, or tribal governments, including soil conservation districts, U.S. Forest Service, and watershed authorities.

Eligibility: Owners, managers, and users of public, private, or tribal lands if their watershed area has been damaged by a natural disaster.

Address: Contact your local or state National Resources Conservation Service office (see “<http://www.nrcs.usda.gov/perdir.html>”); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013

Phone: See above

Facsimile: n/a

E-mail: n/a

Web Site: <http://www.nhq.nrcs.usda.gov/CCS/ewpFs.html>

Environmental Quality Incentives Program

Purpose: To install or implement structural, vegetative, and management practices in priority areas.

Projects: Conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices important to improving and maintaining water quality and the general health of natural resources in the area; and land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management.

Assistance: Cost sharing may pay up to 75 percent of the costs of certain conservation practices. Incentive payments may also be made to encourage a producer to perform land management practices for up to three years. Offers 5-10 year contracts. Maximum of \$10,000 per person per year and \$50,000 for the length of the contract.

Eligibility: Eligibility is limited to persons who are engaged in livestock or agricultural production, excluding most large confined livestock operations.

Address: Contact your local or state National Resources Conservation Service office (see "<http://www.nrcs.usda.gov/perdir.html>"); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-1873 or (202) 720-1845

Facsimile: n/a

E-mail: n/a

Web Site: <http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/eqipfact.html>

Watershed Protection and Flood Prevention

Purpose: Works through local government sponsors to help participants voluntarily plan and install watershed-based projects on private lands.

Projects: Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres.

Assistance: Provides technical and financial assistance. Funds can cover 100% of flood prevention construction costs, 50% of costs associated with agricultural water management, recreation and fish and wildlife, and none of the costs for other municipal and industrial water management.

Eligibility: Local or state agency, county, municipality, town or township, soil and water conservation district, flood prevention or flood control district, tribe or tribal

organization, or nonprofit agency with authority to carry out, maintain, and operate watershed improvement works

Address: Contact your local or state National Resources Conservation Service office (see “<http://www.ncg.nrcs.usda.gov/perdir.html>”); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-3527

Facsimile: n/a

E-mail: n/a

Web Site: <http://www.nrcs.usda.gov/NRCSProg.html>

Wetlands Reserve Program

Purpose: Protect and restore wetlands, riparian areas and buffer zones

Projects: Voluntary program where landowners may sell a conservation easement or enter into a cost-share restoration agreement, while maintaining private ownership.

Assistance: Three options: 1) permanent easement - USDA purchases easement (payment will be the lesser of: the agricultural value of the land, an established payment cap, or an amount offered by the landowner) and pays 100% of restoration costs; 2) 30-year easement - USDA pays 75% of what would be paid for permanent easement and 75% of restoration costs; 3) restoration cost share agreement - 10-year minimum agreement to restore degraded habitat where USDA pays 75% of restoration costs.

Eligibility: Individuals, states, local governments, tribes, or any other entity who owns private land. The land must be owned for at least 1 year and be restorable and suitable for wildlife.

Address: Contact your local or state National Resources Conservation Service office (see “<http://www.ncg.nrcs.usda.gov/perdir.html>”); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 690-0848

Facsimile: n/a

E-mail: RMisso@usda.gov

Web Site: <http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WetRule.html> or <http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WRPfact.html> (fact sheet)

Wildlife Habitat Incentives Program

Purpose: To develop and improve fish and wildlife habitat on private lands.

Projects: Participants prepare a wildlife habitat development plan in consultation with the local conservation district. The plan describes the landowner's goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement.

Assistance: Technical assistance and cost-share agreements where NRCS pays up to 75% of cost of installing wildlife practices. Typically 5-10 year contracts.

Eligibility: Must own or have control of the land and cannot have it enrolled in other programs with a wildlife focus, such as the Wetlands Reserve Program, or use the land for mitigation. Other restrictions may apply.

Address: Contact your local or state National Resources Conservation Service office (see “<http://www.nrcs.usda.gov/perdir.html>”); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-3534

E-mail: n/a

Web Site: <http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WhipFact.html>

DEPARTMENT OF INTERIOR (DOI)
DOI - Fish and Wildlife Service

Coastal Program

Purpose: To conserve healthy coastal ecosystems for the benefit of fish, wildlife, and people.

Projects: Examples of protection include use of conservation easements and fee title acquisition to protect relatively pristine coastal wetlands, salt marshes, prairies, dunes, bottomland hardwood forests, and riparian areas. Examples of coastal habitat restoration include: reintroduction of tidal flow to formerly-diked mud flat and salt marsh habitat, planting of native vegetation (including submerged aquatic grasses), control and monitoring of exotic invasive species, fencing to restore riparian salmon spawning habitat, and removal or retrofit of small dams and culverts to allow for passage of anadromous fish in coastal streams and estuaries.

Assistance: Technical and financial assistance is available. The program focuses exclusively on coastal watersheds. It applies an ecosystem-level approach to resolving resource problems, and targets efforts for a strategic (rather than opportunistic) approach. The program is a non-regulatory, pro-active program that relies on voluntary partnership building. Partners include other federal and state agencies, local and tribal governments, businesses, conservation organizations, and private landowners.

Matching grants are also awarded annually, on a competitive basis. States that border the Atlantic, the Gulf of Mexico, Pacific and Great Lakes are eligible to apply for grants. The one exception is the State of Louisiana, which has its own coastal wetlands program. Trust Territories and Commonwealths of the United States are also eligible for grants.

Eligibility: The Coastal Program funds projects on private and public lands.
Address: Department of Interior, U.S. Fish and Wildlife Service, Division of Fish and Wildlife Management Assistance and Habitat Restoration, 4401 N. Fairfax Drive, Room 400, Arlington, VA 22203. National, regional, and state contacts are listed at <http://www.fws.gov/cep/coastweb.html>
Phone: 703/358-2201
Facsimile: 703/358-2232
Web Site: <http://www.fws.gov/cep/coastweb.html>

Jobs in the Woods Watershed Restoration Program

Purpose: Provides funding to support watershed restoration projects in timber dependent communities within the range of the northern spotted owl through the Northwest Forest Plan (NWFP). The NWFP was created to offset impacts of economic losses to communities in CA, OR and WA, resulting from reductions in timber harvest.

Projects: Program funds are to support watershed restoration projects, including: instream habitat restoration, fish passage improvements, fish screen installation, riparian and wetland habitat restoration, and upland forest restoration, on non-federal lands, while employing workers from timber dependent communities to conduct project work. Projects are focused on implementing habitat improvements to benefit federally listed, proposed or candidate species, under the ESA.

Assistance: The Service provides the grants and assists applicants with obtaining permits and complying with federal laws, including the ESA, NEPA, NHPA, and the Clean Water Act. Most funded projects involve grants of under \$100,000.

Eligibility: Projects must occur on non-federal lands. Non-profit organizations, individuals, private businesses, Native American tribes and state and local governments are eligible.

Address: U.S. Fish and Wildlife Service, Arcata FWO; Jobs in the Woods Watershed Restoration Program; 1125 16th Street, Room 209; Arcata, CA 95521.

Phone: (707) 822-7201
Facsimile: (707) 822-8136
Web Site: <http://www.ccfwo.r1.fws.gov/jitw>

North American Wetlands Conservation Act Grant Program

Purpose: To promote long-term conservation of North American wetland ecosystems and the wildlife that depend on them.

Projects: For on-the-ground wetland and wetland-associated acquisition, creation, enhancement, and/or restoration

Assistance: Regular Grant Program (over \$50k) and Small Grant Program (\$50k or less)

Eligibility: Must form public-private sector partnerships and match grant funds 1:1 with U.S. non-Federal dollars

Address: Department of Interior, U.S. Fish and Wildlife Service, North American Waterfowl and Wetlands Office, 4401 N. Fairfax Drive, Room 110, Arlington, VA 22203 (Attn: specify which grant program you are interested in)
Phone: (703)358-1784
Facsimile: (703)358-2282
E-mail: R9ARW_NAWWO@MAIL.FWS.GOV
Web Site: <http://www.fws.gov/r9nawwo/nawcahp.html>

Partners for Fish and Wildlife Program

Purpose: To conserve, protect, and enhance fish and wildlife and their habitats
Projects: Examples of voluntary habitat restoration: restoring wetland hydrology, planting native trees and shrubs, planting native grasslands, installing fencing and off-stream livestock watering facilities, removal of exotic plants and animals, prescribed burning, reconstruction of in-stream aquatic habitat
Assistance: Financial and technical assistance available. The landowner may perform the restoration and be reimbursed directly for some or all of his or her expenses, the Service may hire a contractor to complete the work, or the Service may complete the work itself. While not a program requirement, a dollar-for-dollar cost share is sought on a project-by-project basis. In some states where the program is very popular, however, a 50:50 cost share is required. Partners for Fish and Wildlife funds are not used to purchase or lease real property interest or to make rental or other incentive payments to landowners. Minimum 10-year contract.
Eligibility: Although the primary partners are private landowners, anyone interested in restoring and protecting wildlife habitat on private or tribal lands can get involved in the Partners for Fish and Wildlife Program, including other federal, state and local agencies, private organizations, corporations, and educational institutions.
Address: Contact your state office for assistance. National, regional and state contacts are listed at <http://www.fws.gov/r9dhcpfw/CONTACTS/altcont.html>; U.S. Fish and Wildlife Service, Division of Fish and Wildlife Management Assistance and Habitat Restoration, 4401 N. Fairfax Drive, Room 400, Arlington, VA 22203
Phone: (703) 358-2161
Facsimile: (703) 358-2232
Web Site: <http://www.fws.gov/r9dhcpfw/>

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) *NOAA - National Marine Fisheries Service*

NOAA Community-Based Restoration Program

Purpose: To restore marine fish habitat by fostering partnerships with local communities
Projects: Community-based restoration efforts that benefit marine fish habitat (including coastal wetlands and anadromous fish streams)

Assistance: Small grants available - should be developed in partnership with local National Marine Fisheries Service office
Eligibility: non-profits, state and local agencies, tribes
Address: National Marine Fisheries Service, Office of Habitat Conservation, Restoration Division, 1315 East-West Highway, Silver Spring, MD 20910.
Phone: (301) 713-0174
Facsimile: (301) 713-0184
E-mail: chris.doley@noaa.gov or robin.bruckner@noaa.gov
Web Site: <http://www.nmfs.gov/habitat/restoration>

ARMY CORPS OF ENGINEERS (CORPS)

CORPS--Civil Works Directorate

Planning Assistance to States Program, Section 22 of the Water Resources Development Act

Purpose: To allow the Corps of Engineers to perform technical studies for management of water and related land resources to help states and Indian tribes deal with their water resources problems. The program is limited to a maximum of \$500,000 per state or tribe in any year.

Projects: Typical activities studied under this Program are flood damage reduction, water resources development, water supply, water conservation, water quality, erosion, wetlands evaluation, and navigation.

Assistance: This is not a grant program. The local sponsor of the study shares in the cost of the study.

Eligibility: Studies are initiated based on requests to the appropriate Corps of Engineers District office by the local sponsor.

Example: In Louisiana, Section 22 funds were used to cost-share in a study to plan and design a hiking/biking/recreation trail compatible with existing levee systems and other floodplain improvements. The local sponsor then implemented the trail design using non-Federal funding sources.

Address: Contact your local district office of the Army Corps of Engineers.

Phone: n/a

Facsimile: n/a

Email: n/a

Website: <http://www.usace.army.mil/>

Beneficial Uses of Dredged Material, Section 204 of the Water Resources Development Act

Purpose: To allow the Secretary of the Army to carry out projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including

wetlands, in connection with dredging for construction, operation, or maintenance by the Secretary of an authorized navigation project.

Projects: Work must be for the protection, restoration and creation of aquatic and ecologically related habitat, including wetlands. Examples include: placement in subsiding wetlands to re-establish necessary elevations for vegetation, additions to offshore islands to re-establish submerged areas and nesting habitat, filling deep holes to re-establish wetlands.

Assistance: This is not a grant program. A local sponsor, a governmental entity, must partner with the Corps. The non-federal share is 25% of the costs in excess of the costs necessary to carry out the dredging for the authorized navigation project.

Eligibility: Studies are initiated based on request to the appropriate Corps of Engineers District office by the local sponsor.

Example: Battery Island Bird Habitat Preservation, Cape Fear River, North Carolina. Battery Island is owned by the State of North Carolina and administered by the North Carolina Division of Parks and Recreation. The Ecosystem Restoration Project will protect 10 acres of upland nesting habitat for colonial waterbirds from further erosion. The project will also restore 5.5 acres of valuable colonial waterbird nesting habitat by placement of dredged material obtained from periodic dredging of the adjacent Wilmington Harbor navigation project.

Address: Contact your local district office of the Army Corps of Engineers.

Phone: n/a

Facsimile: n/a

Email: n/a

Website: <http://www.usace.army.mil/>

Aquatic Ecosystem Restoration, Section 206 of the Water Resources Development Act

Purpose: To allow the Corps to carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest and are cost-effective.

Projects: Work has to be related to aquatic restoration. Examples include reforestation of bottomland hardwoods, modification of stream channels to stabilize channels, while introducing complexity and fish habitat, riparian re-vegetation, improvement of fish passage, which may include dam removal, re-establishing submerged vegetation, restoration of reclaimed land, restoration of wetlands.

Assistance: A non-federal sponsor, a public entity, must partner with the Corps. The non-Federal share is 35% of the total project cost, including study phase cost. The non-Federal sponsor is also responsible for 100% of the operation, maintenance, repair and rehabilitation cost.

Eligibility: Studies are initiated based on request to the appropriate Corps of Engineers District office by the local sponsor.

Example: At the Ladd Marsh Wildlife Area, 6 miles southeast of LaGrande, Oregon, the State of Oregon teamed with the Corps to restore the meandering pattern and

riparian vegetation of an approximately 4,000-foot section of Ladd Creek and a 2,000-foot section of Barney Creek. This project enhances habitat for resident rainbow trout as well as the steelhead trout, which is listed under the Endangered Species Act for protection in the entire Snake River Basin.

Address: Contact your local district office of the Army Corps of Engineers.

Phone: n/a

Facsimile: n/a

Email: n/a

Website: <http://www.usace.army.mil/>

Other Funding Source Documents:

“Catalog of Federal Domestic Assistance”. Published biannually by General Services Administration. <http://aspe.os.dhhs.gov/cfda>, (202) 708-5126.

“Catalog of Federal Funding Sources for Watershed Protection, 2nd Edition” (1999). EPA’s Watershed Academy, Office of Water, Publication No. EPA 841-B-99-003. <http://www.epa.gov/OWOW/watershed/wacademy/fund.html>, National Center for Environmental Publications and Information (NCEPI), (800) 490-9198.

“Environmental Grantmaking Foundations”. Published annually by Resources for Global Sustainability, Inc. <http://home.eznet.net/~rgs>, (716) 473-3090.

“Exploring Wetlands Stewardship- A Reference Guide for Assisting Washington Landowners” (1996). Washington State Department of Ecology Publication No. 96-120. <http://www.wa.gov/ecology/sea/shorelan.html>, (360) 407-7472.

“Financing Clean Water Action Plan Activities” (1998), EPA Clean Water Act State Revolving Fund Branch, Office of Water. www.epa.gov/owm/finan.htm, (202) 260-2036.

“Funding for Habitat Restoration Projects” Citizen’s Guide: A Compendium of Current Federal Programs with Fiscal Year 1996–1998 Funding Levels”. Restore America’s Estuaries. <http://www.estuaries.org/funding.html> or e-mail: raecoalition@estuaries.org

“A Guidebook of Financial Tools” (1997). Environmental Finance Center Network and the Environmental Financial Advisory Board. <http://www.epa.gov/efinpage/guidebk/guindex.htm> or e-mail: mcprouty.timothy@epa.gov

“Landowners Guide to Voluntary Wetland Programs in Arkansas”, Arkansas Game and Fish Commission. http://www.mawpt.org/MAWPT_Products/ or (501) 223-6300.

“Landowning Colorado Style”, Colorado Association of Soil Conservation Districts, (303) 232-6242.

“Living with Michigan’s Wetlands: A Landowner’s Guide”. Tipp of the Mitt Watershed Council, (616) 347-1181.

“Ohio Wetlands”. National Audubon Society's Great Lakes Regional Office, (614) 224-3303.

“Options for Wetland Conservation: A Guide for California Landowners”. California Resources Agency. www.ceres.ca.gov/wetlands/introduction/opt_guide.html or (916) 653-5656.

“The Oregon Wetlands Conservation Guide: Voluntary Wetlands Stewardship Options for Oregon’s Private Landowners” (1995). Oregon Wetlands Conservation Alliance. Contact Oregon Department of Agriculture, Natural Resources Division at (503) 292-9451.

“Private Landowner’s Wetlands Assistance Guide: Voluntary Options for Wetlands Stewardship in Maryland” (1992). Contact EPA Region III at (215) 566-2718.

“A State and Local Government Guide to Environmental Program Funding Alternatives” (1994). EPA document #EPA 841-K-94-001, Office of Water.

“Wetland and Riparian Stewardship in Pennsylvania: A Guide to Voluntary Options for Landowners, Local Governments and Organizations” (1997). Alliance for the Chesapeake Bay. Contact the Bureau of Watershed Conservation, Pennsylvania Department of Environmental Protection, (717) 236-8825.

“Wetlands Assistance Guide for Landowners (in Texas)”. Texas Parks and Wildlife. <http://www.tpwd.state.tx.us/conservation/wetlands/wetintro.htm> or (512) 389-4328.

APPENDIX R-III: ORGANIZATIONS, WEB SITES, AND TRAINING OPPORTUNITIES

Below is a list of sources of assistance and information on wetland restoration. It is not a comprehensive list, but is a good introduction to what is available.

Nonprofit Organizations:

NAME	CONTACT INFORMATION
Association of State Floodplain Managers	2809 Fish Hatchery Road, Suite 204 Madison, WI 53711, (608)274-0123, http://www.floods.org/ asfpm@floods.org
Association of State Wetland Managers	PO Box 269, Berne, NY 12023-9746 (518)872-1804, http://www.aswm.org/ aswm@aswm.org
Ducks Unlimited, Inc.	One Waterfowl Way, Memphis, Tennessee, USA 38120 1(800)45DUCKS, http://www.ducks.org/ conserv@ducks.org
Environmental Law Institute	1616 P St., NW, Suite 200 Washington, DC 20036, (202)939-3800 http://www.eli.org/ , widholm@eli.org
Estuarine Research Federation	http://www.erf.org/ , webmaster@edf.org
Izaak Walton League of America	707 Conservation Lane, Gaithersburg, MD 20878, (800)BUG-IWLA (284-4952), http://www.iwla.org/ general@iwla.org
Native American Fish and Wildlife Society	750 Burbank Street, Broomfield, CO 80020, (303) 466-1725, www.nafws.org/index/html
Soil and Water Conservation Society	7515 NE Ankeny Road, Ankeny, Iowa 50021, (515)289-2331, http://www.swcs.org

Society for Ecological Restoration	1207 Seminole Highway Madison WI 53711 USA, (608)262-9547, http://ser.org/ , ser@vms2.macc.wisc.edu
Society of Wetland Scientists	P.O. Box 1897, Lawrence, Kansas 66044-8897, 1(800)627-0629, http://www.sws.org/ , sws@allenpress.com
Terrene Institute	4 Herbert Street, Alexandria, VA 22305, (703)548-5473, http://www.e2b2.com/index.ht , terrinst@aol.com
Water Environment Federation	601 Wythe Street, Alexandria, VA 22314-1994 USA, 1(800)666-0206, http://www.wef.org/ , msc@wef.org

Federal Agency Web Sites:

AGENCY	INTERNET ADDRESS
Army Corps of Engineers	http://www.usace.army.mil/
Bureau of Reclamation	http://www.usbr.gov/
Bureau of Land Management	http://www.blm.gov/
Council on Environmental Quality	http://www.whitehouse.gov/CEQ/About.html
Department of Agriculture	http://www.usda.gov/
Environmental Protection Agency's Office of Wetlands, Oceans and Watersheds	http://www.epa.gov/OWOW/wetlands/restore
Farm Service Agency	http://www.fsa.usda.gov/pas/default.asp
Fish and Wildlife Service	http://www.fws.gov/
Forest Service	http://www.fs.fed.us/
Geological Survey	http://www.usgs.gov/

National Oceanic and Atmospheric Administration, National Marine Fisheries Service	http://www.nmfs.noaa.gov/habitat/habitatprotection/wetlands.htm http://www.nmfs.noaa.gov/habitat/restoration/
National Park Service	http://www.nps.gov/
Natural Resources Conservation Service	http://www.nrcs.usda.gov/
Office of Surface Mining	http://www.osmre.gov/osm.htm
State Department's Bureau of Oceans and International Environmental and Scientific Affairs	http://www.state.gov/www/global/oes/

Other Web Sites:

DESCRIPTION	INTERNET ADDRESS
Better Wetlands: More Than a Dozen Ideas to Improve Restored Wetlands for Wildlife and Personal Enjoyment (U.S. Natural Resources Conservation Service)	http://www.ia.nrcs.usda.gov/enhance/bwtoc.html
Do Created Wetlands Replace the Wetlands that are Destroyed? (U.S. Geological Survey)	http://www.dwidn.er.usgs.gov/widocs/wetlands/FS_246-96.html
Evaluation of Restored Wetlands in the Prairie Pothole Region	http://www.NPWRC.USGS.GOV/wetland/
Monitoring Water Quality Web Page: Resources for Volunteer Monitors (USEPA)	http://www.epa.gov/OWOW/monitoring/
"Riverine Wetlands: Succession and Restoration" - bibliography and abstracts of scientific articles, dissertations and books (University of Lyon, France)	http://limnologie.univ-lyon1.fr/htdocs_limno/publications.html
Stream Corridor Restoration: Principles, Practices, and Processes (Interagency)	http://www.usda.gov/stream_restoration/

Volunteer Estuary Monitoring (USEPA)	http://earth1.epa.gov/OWOW/monitoring/volunteer/estuary/index.html
Wetland Bioassessment Fact Sheets (USEPA)	http://www.epa.gov/owow/wetlands/wqual/bio_fact/
Wetland Creation and Restoration: The Status of the Science (USEPA)	http://www.epa.gov/OWOW/wetlands/kusler.html
Wetland Research: Restoring the Balance (LWRRDC)	http://www.ramsar.org/wurc_library_research.html
WES Environmental Laboratory - Wetlands (US Army Corps of Engineers)	http://www.wes.army.mil/el/wetlands/wetlands.html#wrtc

Training Opportunities:

The following are training opportunities offered by nonprofit, government, and academic organizations. There are also many private firms not listed here that have wetland training courses available.

NAME/DESCRIPTION	CONTACT INFORMATION
Certified professional in erosion and sediment control (CPESC) - Certification training	Soil and Water Conservation Society 7515 NE Ankeny Road, Ankeny, IA 50021 (515) 289-2331 ext.17, http://www.swcs.org/cpesc.ht , pamd@swcs.org
Desert research institute water resources center - Courses available	Water Resources Center, Desert Research Institute, P.O. Box 60220, Reno, NV 89506-0220, USA, (702)673-7300, http://www.dri.edu , wwwsrc@dri.edu
Interagency training opportunities and non-government training partners - Internet training list (hot links to natural resources training web pages)	Bureau of Land Management National Training Center, 9828 N 31st Ave, Phoenix, AZ 85051, USA, (602)906-5500 http://www.ntc.blm.gov/partner.html

NAME/DESCRIPTION	CONTACT INFORMATION
Izaak Walton League's Save Our Streams program training workshops - Short workshops (volunteer wetlands and streams monitoring, quality assurance, restoration)	Save Our Streams, Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878, USA, (301)548-0150, http://www.iwla.org/ , sos@iwla.org
Mid-Atlantic interagency wetland training - Free courses (delineation, plants, soils, hydrology)	(215)814-2718, spagnolo.ralph@epa.gov
Society of Wetland Scientists professional certification program	SWS Professional Certification Program, P. O. Box 1897, 810 East 10th Street, Lawrence, KS 66044-8897 USA, 1(800)627-0629, http://www.wetlandcert.org/ , swscertif@allenpress.com
U.S. Department of Agriculture (Natural Resources Conservation Service) training workshops on water quality monitoring - Free	Bruce Newton, National Water and Climate Center, USDA Natural Resources Conservation Service, 101 SW Maine Street, Suite 1600, Portland, OR 97204-3224, USA, (503)414-3055, bnewton@wcc.nrcs.usda.gov
U.S. Fish and Wildlife Service's National Conservation Training Center (NCTC) Courses	NCTC, Rt.1, Box 166, Shepherdstown, West Virginia 25442, USA, (304)876-7445 http://www.fws.gov/r9nctc/nctc.html , dee_butler@mail.fws.gov
Watershed training opportunities through The Watershed Academy - Free	Watershed Academy, U.S. Environmental Protection Agency (4503F), 401 M Street, SW, Washington, DC 20460, USA, (202)260-5368, http://www.epa.gov/owow/watershed/wacademy.htm , wacademy@epamail.epa.gov
Wetland Biogeochemistry Institute (delineation training and biogeochemistry Symposia)	Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, Louisiana 70803-7511, USA, (504)388-8810, http://www.leerica.lsu.edu/ , wetlands@premier.net

NAME/DESCRIPTION	CONTACT INFORMATION
WETLAND program short courses at Ohio State University (wastewater treatment, delineation, mitigation)	Wetlands Program c/o William J. Mitsch, The Ohio State University, School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210, USA, (614)292-9773, http://swamp.ag.ohio-state.edu/ , mitsch.1@osu.edu
Wetland-related academic programs and training courses - two internet listings	Society of Wetland Scientists Business Office, P.O. Box 1897, Lawrence, Kansas 66044-8897, USA, 1(800)627-0629. For academic programs - http://www.sws.org/colleges/ For training courses - http://www.sws.org/training/ , sws@allenpress.com or mingst@mail.modot.state.mo.us
U.S. Army Corps of Engineers Proponent-Sponsored Engineer Corps Training (PROSPECT) environmental training courses on wetlands and restoration	http://www.wes.army.mil/el/nrrdc/train.html

TECHNICAL APPENDICES

APPENDIX T-I: Societal Goals and Related Ecological Functions of Wetlands (adapted from NRC, 1995)

<i>Social Goal</i>	<i>Ecological Function</i>	<i>Ecological Effects</i>	<i>Physical Indicator*</i>	<i>Measurement Parameters</i>
Provide fish and shellfish habitat	Long-term surface water storage	Maintain base flows	Basin capacity; presence of water during fish lifecycle (hydrological regime); typical water quality; substrate to water level elevations allow water flow and retention	* Basin volume * Water level changes * Water quality measures (temp, salinity, etc.) * Substrate elevations * Channelization patterns
	Support typical communities	Food, cover abundance	Plant species diversity and richness	* Spp number, abundance * Spp height, cover, structure * Growth, reproductive rates
Support waterfowl and furbearers	Maintain typical plant communities	Food, nesting, cover for animals	Mature wetland vegetation; typical mosaic of plant community successional stages	* Spp number, abundance * Population growth parameters: breeding pairs, offspring produced, mortality, immigration/emigration * Sources of mortality
Provide useful plants	Support typical plant communities	Maintain nutrient levels within wetland	Survival and reproduction of particular species	* Growth, reproduction rates * Sustainable crop yields

<i>Societal Value</i>	<i>Ecological Function</i>	<i>Ecological Effects</i>	<i>Physical Indicator</i>	<i>Measurement Parameters</i>
Maintain water quality	Retention, removal of dissolved materials	Reduced transport of nutrients	Nutrient outflow lower than inflow	* N and P levels in incoming versus outgoing waters; * N and P levels in wetland sediments
	Accumulation of peat (organic matter)	Retain pollutants, nutrients, metals	Increase in depth of peat; presence of pollutants in peat	* Change in depth of peat layer * Analysis of heavy metals and other pollutants in soil cores
	Accumulation of sediments (inorganic)	Retain sediments, some nutrients	Increase in depth of sediment	* Change in depth of sediment layer
Reduced shoreline erosion	Maintain vegetated wetland edges	Stable shoreline edges	Erosion and deposition rates typical of wetland type; lack of eroded or undercut shore; presence of stable vegetation	* Soil loss rates from edges * Undercutting and down cutting changes * Plant loss from edges
Reduced damage from floodwaters	Short-term surface water storage	Reduced down-stream flood peaks	Presence of floodplain along river corridor; wide vegetation buffer; basin capacity	* Width of floodplain and riparian vegetation * Basin volume
Maintain biodiversity	Maintain high water table	Support typical plant community	Presence of diverse native plant species	* Spp number, abundance, richness * Complete food chain
	Maintain typical energy flow	Support for animal populations	High diversity of animal species	* Few to no non-native spp * Rare and dominant spp * Spp succession

* Physical Indicators include both measurable processes and structures of the system.

APPENDIX T-II: What makes a Wetland Unique?

Although they are varied in type and location, wetlands possess several ecological characteristics that distinguish them from upland or aquatic habitats. Wetlands are characterized by unique hydrologic, soil (substrate), and biotic conditions that set them apart from other systems. Each of these characteristics is described in detail below to provide you with a basic understanding of the ecological elements that wetland restoration, enhancement, or creation projects seek to establish.

Hydrology and Water Quality

Wetland hydrology generally exists when an area is wet enough to result in soils that are anaerobic (depleted of oxygen) and support hydrophytic vegetation (plants that are adapted to anaerobic, waterlogged environments). The hydrological regime is typically the primary factor driving the rest of the elements of the system.

Wetland hydrology may exist at sites that are obviously flooded or at sites that are never flooded but have soils that are saturated near the surface. A site's hydrologic characteristics are the most important factors in determining what kind of wetland will exist and what functions it will perform. The hydrologic characteristics of a wetland are commonly described in terms of water depths over time, flow patterns, and duration and frequency of flooding or saturation. Some systems, such as streams, have very dynamic hydrological regimes that can be difficult to re-create. Other wetlands, such as permanent ponds or bogs, have hydrological conditions that are more static.

The presence of water on a site can be measured and illustrated with a hydrograph. A hydrograph indicates the level of water or the depth of soil saturation over the year. Figure A-1 shows the water signatures for a tidal marsh and a prairie pothole. Some wetlands have fairly stable hydrographs; however, most fluctuate based on seasonal precipitation, temperature, and evaporation.

Hydrographs for wetlands in coastal areas will be heavily influenced by tidal cycles. Inland wetland hydrographs, such as those for prairie potholes, may show the strong influence of ground water levels.

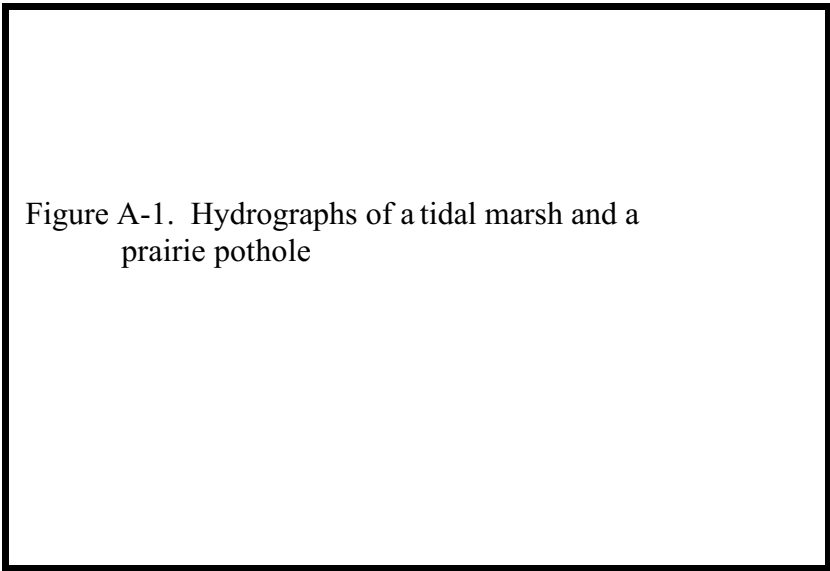


Figure A-1. Hydrographs of a tidal marsh and a prairie pothole

Many wetlands are dynamic and fluctuate in size during the year and between years. These natural fluctuations are the wetland's disturbance regime and this regime needs to be included in the design for your wetland site. Sites may flood on regular 2, 10, or 50 year cycles and cause significant, but predictable changes in wetland size and shape. Extreme events, such as hurricanes, may have less predictable effects.

If wetland hydrology can be established at your site, there is a good chance that other wetland characteristics will develop over time. When a wetland project does not develop as planned, or does not develop into a wetland at all, it is most often because the hydrologic characteristics of the site are not what they need to be to achieve the goals. The first step in trouble-shooting wetland projects is to check the hydrologic characteristics of the site.

For many sites, establishing the proper hydrology requires the services of a hydrologist who will assess current conditions on your site, evaluate the local disturbance regime, and determine what changes are necessary to achieve the hydrological regime typical of the wetland you wish to establish.

Water contains a number of dissolved and suspended materials including nutrients (e.g., nitrogen, phosphorus, dissolved carbon), contaminants (e.g., pesticides, petroleum hydrocarbons), and other constituents (e.g., dissolved oxygen, salts, metals, suspended sediments). Some chemicals (e.g., nutrients) can be either beneficial or toxic, depending on how much is present. Water quality usually refers to how "healthy" the water is for humans, animals and plants. An aquatic area with "good" water quality has the water chemistry typical of the ecosystem and region, including the levels of dissolved oxygen, contaminants, and other constituents (nutrients, suspended sediments) that result in healthy populations of native plants and animals.

Because wetland types vary, good water quality varies from one wetland type to another. For example, significant amounts of suspended sediments are typical of good conditions for some tidal marshes because, as sediments settle out, they help to build up the marsh surface, which allows the growth of marsh vegetation. Conversely, too much suspended sediment in coastal waters can be harmful to seagrass beds because it reduces the amount of light penetrating the water to the plants. If you suspect that the water quality might be a problem, you will need to compare the water condition at your site with those at reference wetlands, i.e., sites in your region that are relatively undisturbed examples of your wetland type. This work will almost always require the expertise of a water quality specialist.

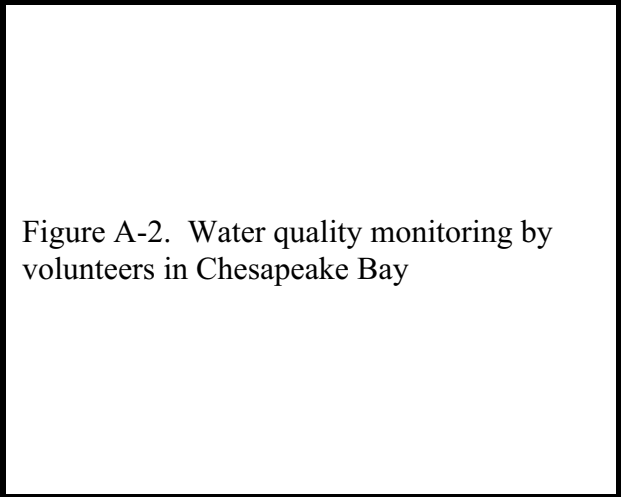


Figure A-2. Water quality monitoring by volunteers in Chesapeake Bay

Wetland Soils and their Qualities

Wetland soils or substrates are hydric soils, meaning they are waterlogged for all or part of the year which results in anaerobic conditions. In hydric soils, water fills the air spaces between soil particles and forces the oxygen out causing soils to become anaerobic (depleted in oxygen) in the zones closest to the surface. Waterlogged, anaerobic conditions are very hostile to terrestrial plants and these conditions will quickly kill most upland species. As a result, wetlands are dominated by plants that are specifically adapted to these tough, waterlogged, anaerobic soil conditions. When soils lose their oxygen, they change significantly in structure and chemistry which also influences the plant and animal species able to survive there.

Wetland soils come in two major types—organic and mineral. Organic soils are made up primarily of plant material, either decomposed (the soil is then called “muck”) or undecomposed (called “peat”). Mineral soils are composed primarily of non-plant material such as quartz, biotite, or calcite. Depending on the size of the soil grains, mineral soils are generally described (from largest grain size to smallest) as sand, silt, and clay. Sandy wetland soils are the most permeable, allowing water to move easily between the wetland and the groundwater, depending on the depth of the water table. Less permeable clayey soils are more likely to maintain water in the wetland even if the water table is low. Some sites have “hard pan” layers underneath them, impermeable layers of clay or rock, essential to the ecology of the wetland. These hard subsurface layers may allow water to stay ponded for much longer than would occur otherwise, resulting in unique ecosystems, such as “vernal pool” habitats.

Many wetland soils, especially organic soils such as peat, are characterized by relatively high amounts of organic carbon and nutrients, which drive the significant biological productivity of wetlands. The organic material provides energy for soil microbes to recycle nutrients and to convert nitrogen to organic forms that encourage plant growth. Of course, not all soils are naturally high in organic material or nutrients. As with other wetland elements, soil characteristics vary with the system and the region. Reference sites can provide data on typical soil conditions of the region. Soil scientists can identify hydric soils by their color and structure. Often organic, anaerobic soils are dark grey to nearly black. In more mineral soils, the chemistry of hydric soils affects minerals such as iron and manganese causing distinctive color variations.

In addition to small scale soil qualities, two large scale features of substrates are critical to restoration projects: 1) soil or substrate elevation in relationship to water levels, and 2) networks of channels to move water in and out. These features are shaped by water and their relationship to water levels is critical. Incorrect elevations and topographies are some of the most common reasons wetland restoration projects fail to achieve their goals.

Soil maps produced by the USDA Natural Resources Conservation Service (NRCS) are a good place to start for local soil information. Soil maps are produced for each county and provide information on the presence of hydric soils, the permeability of these soils, and their suitability as wetland habitat. However, some county maps are decades old, and most do not contain enough detail to locate small hydric “inclusions” in non-hydric soils (or vice-versa). You may need to have a professional soil scientist examine the soils at the project site, particularly if the site has been altered, to determine whether the existing soil is hydric. Determining proper

soil elevations and topography, if they have been altered, is the job of hydrologists or wetland experts who deal with sediments and their transport.

Wetland Plants

Wetland plants, or hydrophytic plants, are specifically adapted to waterlogged, anaerobic conditions. Some wetland plants grow exclusively in wetlands and are called “obligate” wetland species; others are “facultative” species as they may be found in both wetlands and drier areas. There are many types and categories of wetland plants, including emergent plants (such as rushes), submerged plants (eel grass), and floating plants (such as duckweed). Wetland plants also include trees (like swamp oak), shrubs (like bayberry), moss, and many other types. The wetland’s water source (fresh, saline (salty), or brackish) will affect the composition of the wetland plant community, as will the amount and duration of water in the wetland.

Plant species also can be regionally and locally specific: the dominant native plant in Atlantic coast tidal systems is smooth cordgrass (*Spartina alterniflora*) whereas the dominant native plant in central Pacific coast salt marshes is Pacific cordgrass (*Spartina foliosa*). Some wetlands may be degraded because they contain non-native species, that is, plants from other regions. These non-natives may be invasive and displace more typical wetland plants. Sometimes non-native species can completely replace the natural wetland plant community, which alters the ecological functioning of the site. Purple loosestrife, reed canary grass, and common reed are examples of non-native invasive wetland plants. Atlantic cordgrass becomes an invasive, exotic species when it occurs along the Pacific coast, outside its native range.

The spread of non-native species is a huge ecological problem in the U.S. The U.S. Fish and Wildlife Service estimates that approximately 4600 acres per day are lost to non-native plants and animals. For many restoration and enhancement projects, significant effort is devoted to removing the invaders so that the native species can re-establish.

Nutrient, turbidity, and salinity levels are key parameters determining the composition of wetland plant community. Another critical element is the relationship of water levels to substrate elevation. If water is too deep, emergent and sub-emergent vegetation will not establish. If the substrate elevation is too high, then what you may get is an upland. In some habitats, such as vernal pools, microtopographic changes must be re-created to establish the very sensitive endemic species that occur there.

Wetland Animals

Wetlands are inhabited by creatures large and small: water fleas and alligators; shrews and bears; minnows and salmon; wrens and herons. Because wetlands exist where land and water meet, they are often used by animals from both wet and dry environments. Many species depend on wetlands for all or part of their lives. For example, the salt marsh harvest mouse lives its entire life in the tidal salt marshes around the San Francisco Bay. It is so well adapted to this habitat that it has developed special kidney functions that allow it to eat salt marsh vegetation and survive the ingestion of sea water. Wetlands are very important in maintaining biodiversity;

they are used by 43 percent of the species listed as endangered or threatened under the Endangered Species Act.

Some of the smallest wetland animals are invertebrates (animals without backbones) such as beetles, water fleas, crayfish, dragonflies, snails, and clams. Invertebrates are an important food source for other animals, both as adults and in their egg and larval forms. Amphibians and, to a lesser extent, reptiles, are very strongly tied to wetlands because many frogs, snakes, turtles, and salamanders need both water and drier environments to complete their life cycles. Fish are not found in all wetlands, but wherever there is permanent water fish are likely to occur. Even wetlands with only seasonal flooding may be temporary habitat for fish from adjacent permanent water. Many fish spawn in wetlands, and wetlands are particularly valuable as nursery areas where young fish can hide from hungry predators until they are big enough or fast enough to survive in open water.

Birds are some of the best-known inhabitants of wetlands. Ducks, in particular, are valuable to people who enjoy hunting or birding. However, wetlands are also important to shorebirds (plovers, sandpipers) that feed in mudflats, wading birds (herons, egrets, bitterns) that feed in shallow water, songbirds (red-winged blackbirds, rails, marsh wrens) that perch on or nest in tall grasses or shrubs, and other birds such as terns and hawks that are all common inhabitants of wetlands. Finally, mammals such as beavers, raccoons, shrews, mice, moose, and bear are common residents of wetlands, although their tracks are usually seen more often than the animals themselves.

While the ecological requirements for animals vary with the species, here are a few general requirements of major taxa using wetlands:

- Invertebrates process nutrients and organic matter and are important for supporting much of the wetland food chain. Invertebrate species are numerous and live in a range of ecological conditions. In general, like most aquatic animals, most invertebrates need well-oxygenated water. Temperature levels and food sources are essential to support invertebrate diversity. A reliable source of water, a diversity of typical plant species, and buffers around the wetland will support invertebrates by filtering out pollutants, moderating temperature, providing a variety of habitats, and providing food sources.
- Amphibians and reptiles (herptiles) require a range of habitats during their lifecycles. Plant structural diversity, such as brush, leaf litter, and small dense stands of grass or reeds, can give these species cover, foraging and nesting habitat. Larger debris like logs are attractive for basking. Areas of sandy soil with a warm, southern exposure encourage turtle reproduction. Deep water areas will support species that overwinter by burrowing in mud. Shallow water (usually with vegetation) is important for hiding egg masses and protecting tadpoles from predators. Gradual slopes from the wetland to the upland help animals move easily between habitats. Habitat requirements vary by species and restorations should be designed with the needs of local herptile species in mind.

- Fish need both shallow water to protect eggs and young fish, and deeper water for adults. Fish may move in and out of wetlands as water depths fluctuate. Some wetlands support no fish or only small fish because the wetland is shallow or temporary. Temperature, dissolved oxygen (DO), and salinity levels are parameters that will determine the species present. Shade, streambed/wetland structure, and food sources (such as invertebrates) will also determine the species richness. Trees for shade and large debris for hiding can be very beneficial. Some fish can provide insect control in the wetland. However, others, such as bottom-feeding fish can destroy submerged plant communities and thereby reduce light levels by stirring up sediment.
- Birds occupy a variety of habitats in and around wetlands and are important indicators of wetland functioning. Breeding or migratory waterfowl and shorebirds will be present in wetlands that offer adequate cover and food sources. Rare species can be indicators of specific habitat conditions. For example, clapper rail populations in west coast tidal salt marshes, are indicators of mature, healthy Pacific cordgrass marshes. A wide range of bird species, including wrens, sparrows, and yellowthroats, live and nest in wetlands or where the wetlands interface with the upland. Adjacent uplands, especially grass, willow, and tree dominated zones, are important as high tide refuges for wetland birds and offer millions of migratory birds places to stop and forage. In developing wetland enhancement activities to attract particular species, carefully weigh the potential effects on other species that use the wetland. Restorationists have also found that some birds can be very destructive to newly installed plants; geese, for example, are able to denude acres of newly planted stems in one night and they can be one of the biggest challenges to new wetland restoration sites.
- Mammals generally need adjacent uplands or upland islands for escape during high-water periods. Therefore, undisturbed upland buffers and corridors connecting adjacent habitats are critical to these taxa. Nest boxes may attract bats, which can provide insect control in the wetlands. Muskrats can help to control vegetation, but can also “eat-out” the vegetation and be a nuisance with burrowing activities. Beavers, a keystone species of wetlands throughout North America, can aid wetland restoration by creating the very water control structures that are needed to keep water in a wetland, but they also can *redesign* your site by creating dams where you didn’t plan for them.

The conversion of wetland vegetation to non-native plants alters the habitat for native animals and results in the loss of species from local wetlands. In addition, non-native animals are as big a problem as non-native plants. Non-native animals are causing losses of wetland communities and biodiversity (see box on nutria).

Animal communities vary with wetland type and region, but in general, healthy wetlands are rich in wildlife and very productive biologically. For example, approximately three-quarters of the Nation's commercially harvested fish and shellfish depend on bays and other estuarine habitats, of which wetlands are an integral part. According to some estimates, each year the production associated with these wetlands accounts for more than \$100 billion dollars in sales of fish and shellfish and provides one and a half million jobs.

Each wetland has its own distinctive animal community. Relatively undisturbed wetlands in your region will give you an idea of what you can expect to inhabit your wetland, as long as your wetland project results in typical wetland hydrology and native plant communities. If you are interested in attracting a particular animal or animals to your wetland, a wetland biologist or ecologist may be able to help you pick specific plants or take other actions designed to accomplish that goal.

Nutria, Non-native Nightmare

Nutria are large (8-18 lb) beaver-like rodents native to South America. Accidentally introduced into Maryland's eastern shore marshes in the 1940's, nutria have been implicated in the loss of emergent brackish marsh.

First noticeable in the 1950s, marsh loss along the Blackwater River in Dorchester County, Maryland, has accelerated at an alarming rate as nutria populations have grown. What was once continuous marshland now appears as fragmented remnants.

Nutria forage directly on the vegetation root mat and cut the marsh into finer and finer fragments. Erosion by tidal and wave action lowers the unvegetated marsh bottom and prevents plants from recolonizing.

A recent study found that within the Blackwater National Wildlife Refuge alone, over 6 square miles of marsh have been lost to open water since 1938. Over 50 percent of the remaining marsh has significant damage and may likely be lost in the near future.

APPENDIX T-III: Activities Used to Restore or Change Wetland Characteristics

Typical Activities Used to Restore or Change Hydrology:

- Try to reverse the actions that caused the loss or alteration of a wetland's hydrologic characteristics. Some measures include:
 - * Remove dams or other water control structures
 - * Fill or plug ditches or drains
 - * Remove fill that has elevated the land surface
- Bring additional water to the site if the current water supply is inadequate. Methods include:
 - * Dig channels to bring water to additional areas
 - * Pumping water in from other sites
 - * Installing pipes to bring in water
- Control water levels by installing water control structures. Some structures include:
 - * Open culverts
 - * Culverts with manual or automatic gates
 - * Weirs
 - * Check dams
- Use the lowest maintenance water control structures possible. Seek structures that allow flexibility in use and are able to withstand extreme hydrological and climactic (e.g. winter ice) events
- Reinstall proper substrate to water level elevations. Some methods include:
 - * If the substrate elevation is too low, allow natural sedimentation to build up the elevation (a passive method).
 - * If the substrate elevation is too low, import appropriate sediment/soils (an active method). Soils may come from upland sites, dredged sites (dredged material), or other wetlands.
 - * If the substrate elevation is too high, excavate to the required level.
 - * Shape and contour your site to re-establish the right relationship between the hydrology of the site and its topography.
- If the primary water source is tidal or groundwater, you may need very precise grading because deviations of only inches can alter the habitat for plants.

Typical Approaches to Improving Water Quality:

- If contaminants are found in the water at the restoration site, check uses and inputs upstream or adjacent to the site for sewer outflows, other outfall pipes, ditches draining industrial or agricultural areas, landfills, or areas where junk and trash has been illegally dumped.
- If you find a potential source of pollution contact local authorities for help to determine whether it is the source of the contaminants and whether it can be cleaned up. Never attempt a clean-up yourself unless you know exactly what you are removing and you own

the property or have the owner's permission. If a site contains contaminants in amounts that are toxic to wildlife or humans, have the toxic materials removed or remediated by professionals.

- If the source of the pollution can't be removed, lessen its impact by:
 - * Implementing "Best Management Practices" (BMPs) to reduce pollution from stormwater runoff from developed areas adjacent to the site. BMPs include activities such as labeling storm drains, installing settling basins, etc.
 - * Planting vegetated upland buffers to reduce the amount of contaminants, excess nutrients, or sediment coming into your site from adjacent or upstream areas.
 - * Selecting plant species that can tolerate the existing conditions.
 - * Routing the water through pools or other structures constructed to allow excess nutrients, sediments, or contaminants to settle out or become absorbed or converted to a less harmful form by natural processes.
 - * Educating neighbors about pollutant effects on wetlands and asking them to reduce their use of fertilizers and pesticides.

Typical Activities for Restoring or Changing Soils/Substrates:

- If soils are degraded or are lacking nutrients, organic matter or other soil component (often the case when wetlands are created from excavated uplands):
 - * Do nothing, and see what plants grow at the site.
 - * Amend the soil with materials designed to address the soil nutrient deficiency. There are scores of amendment approaches. Talk to a specialist to determine the best one for the problems.
 - * Cover the site with wetland soils salvaged from wetlands that are being destroyed.
- If you need to raise the elevation of compacted or eroded sites:
 - * Let natural sedimentation build up the elevation, if the process is fast enough.
 - * Use dredged materials to build up the elevation.
- Provide controls against erosion and sedimentation during construction in or near the wetland or aquatic areas. Common erosion prevention techniques include:
 - * wheat straw (which is longer, thus more stable, than grass/hay straw)
 - * mulch or bales
 - * fiber blankets
 - * cover vegetation (temporary plantings or seeding)
 - * plastic sediment fences with hay bales (be sure they are ultimately removed and do not remain on site or wash downstream).
- Once construction is completed, you may want to delay flooding the site until the exposed soils have been stabilized with vegetation.
- Protect site against long-term erosion. Many methods exist to achieve this goal.

Typical Activities for Establishing a Healthy Wetland Plant Community:

- To establish native species for the target habitat type, after establishing hydrology and soil conditions:
 - * Wait a season or two and see what comes in naturally (assuming wetland hydrology has been established).
 - * Plant wetland vegetation, using local plants or seeds from local nurseries and seed distributors (see USDA's Plant Materials Program for sources of seeds and plants at "<http://Plant-Materials.nrcs.usda.gov/>"). If you are using seeds, ask for a germination test result before you buy.
 - * Salvage plants that would otherwise have been destroyed from local land development, road building, or logging operations, and plant them at your site.
- Follow plant lifecycle needs, including:
 - * Plant early in the species' growing season.
 - * Control water, if possible, to help vegetation become established.
 - * Provide irrigation until young plants are established.
- Control erosion, add nutrients, and establish cover quickly with a fast-growing "cover species" while slower-growing plants become established. Use a leguminous species to boost soil nitrogen, if needed. Never use an invasive or competitive native or non-native species.
- Remove non-native species. The wide range of methods falls into three categories:
 - * Mechanical—pull by hand, use a pulaski or weed wrench, use a blade or backhoe, burn, graze, etc.
 - * Chemical—use a pre-emergent or a herbicide for emergent plants.
 - * Biological—use a biocontrol species, host-specific to the non-native exotic plant.
- Protect new plants from herbivores. Many methods exist, depending on the herbivore, including:
 - * Fencing the planted area.
 - * Putting wire cages around planted seeds, roots, and shoots.
 - * Put seedlings in plastic tubes, which also keep in water.
 - * Put up perching posts to attract birds of prey that feed on animals, such as gophers, which feed heavily on new plants.

Typical Activities for Establishing a Healthy Wetland Animal Community:

- Plant upland species around the wetland to enhance the habitat diversity and act as a buffer. Help with choosing species for wildlife cover and food, erosion control, etc. can be found on the Plant Materials Program website at "Plant-Materials.nrcs.usda.gov/", the National Plant Data Center website at "npdc.usda.gov/npdc/", and the Center for Plant Conservation website at "www.mobot.org/CPC/".
- Create a variety of habitats - different water depths, different vegetation types - to appeal to a variety of animals.

- Tailor nesting and foraging habitats to particular native species, especially rare species, based on information from wildlife specialists and reference wetlands. Typical structures include:
 - * Nest boxes or nesting platforms,
 - * Perches,
 - * Logs and brush,
 - * Islands,
 - * Specific food sources.
- Create a variety of gentle slopes of 3:1 to 20:1 (3:1 means three feet of length for every one foot of rise) similar to those in the reference wetlands.
- Establish connections to other habitats (*e.g.*, channels connecting to larger water bodies, forested corridors connecting to wildlife refuges) unless those areas contain invasive species or other threats.

Figure A-3. Photograph of habitat enhancement at the Hayward regional shoreline, California (Future)

APPENDIX T-IV: Wetland Parameters and Monitoring Methods

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
GENERAL			
Location	use existing map or create map with property boundaries, scale, north arrow, county, state, and landmarks		
Wetland Type	classify existing (if appropriate) and intended type(s) (Cowardin et al., 1979)	classify actual type(s)	classify actual type(s)
Drainage area	identify USGS hydrologic unit from state maps or state watershed unit		map using GIS and appropriate base maps
Surrounding land use	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson et al. 1976)	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson et al. 1976)	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson et al. 1976)
Wetland area	determine wetland boundary and use basic survey techniques to create a map of the site		delineate wetland boundary and use basic survey techniques to create a map of the site

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
Slope	measure slope at intervals along a transect		survey elevations
microtopography	survey elevations every foot or meter on transects traversing the wetland		survey elevations every foot or meter on transects traversing the wetland
HYDROLOGY			
Water depth	above ground: use staff gauge, below ground: use shallow well or 2-3" slotted PVC pipe	above ground: use staff gauge, below ground: use shallow well or 2-3" slotted PVC pipe and read on site	above ground: use automatic water level gauge, below ground: use shallow well or 2-3" slotted PVC pipe with automatic recorder
Flow patterns	direct observation to indicate major pathways and channels on map	direct observation to indicate major pathways and channels on map	regular direct observation or aerial photography to indicate major pathways/channels on map
Flow rates	measure inflow or outflow (if present) with flumes or weirs, measure interior flow with current meters	estimate flow based on rates typical for the area and estimated wetland size	measure inflow or outflow (if present) with flumes or weirs, measure interior flow with current meters
Indirect observations	record observations of high-water marks, drift lines, etc.	record observations of high-water marks, drift lines, etc.	

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
SOIL (sample using soil auger or pit)			
Soil depth	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	take soil core to at least 18 inches deep and have soil expert analyze the soil horizons and their composition
Soil color	use Munsell color chart to determine color of matrix (the dominant color) and any mottles or streaks		use Munsell color chart to determine color of matrix (the dominant color) and any mottles or streaks
Soil texture	use soil texture triangle to classify based on feel (Horner and Raedeke, 1989)	use soil texture triangle to classify based on feel (Horner and Raedeke, 1989)	take a soil core to soils lab for particle size analysis of the different soil horizons
Organic matter	lab analysis for percent organic matter in top layer; include soil moisture measurement		lab analysis for percent organic matter in top layer; include soil moisture measurement
Sedimentation	survey base elevations of completed project	read changes in sediment depth from a staff gauge	survey topography or bathymetry on a yearly basis; or, take sediment cores on a yearly basis for analysis by soils experts

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
VEGETATION			
Species diversity	identify species, document planting locations	identify common species and note number of unidentified species	identify all species, native and non-native
Coverage	estimate coverage to 10%, map plant communities	estimate coverage to 10%, map plant communities	collect plot data along transects, calculate coverage, map plant communities
Survivorship	count plants and determine % of plants alive	visually determine % of plants alive	count plants and determine % of plants alive
Height		measure heights of particular plants on a regular basis	measure heights of randomly chosen plants for a valid statistical comparison
Structure		count stems and branching of particular plants on a regular basis	count stems and branching of randomly chosen plants for a valid statistical comparison
Reproduction		of particular plants, determine the number blooming and setting seed each year	determine percentage of randomly chosen plants blooming and setting seed each year; count new seedlings in randomly chosen plots

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
ANIMALS			
Observations	record direct and indirect observations of wildlife, fish, and invertebrates	record direct and indirect observations of wildlife, fish, and invertebrates	
Habitat evaluations	Use Habitat Evaluation Procedures (FWS 1980) or comparable method for selected species		use Habitat Evaluation Procedures (FWS 1980) or comparable method for selected species
Species diversity and abundance	use trapping or point count methods as required to determine diversity and abundance of indicator species	count bird species and their abundances on a regular (at least quarterly) basis; ask local Audubon chapter for any data	use trapping, point count or other quantitative method as required to determine diversity and abundance of indicator spp
Species survivorship			mark and recapture study
Breeding success		record any species breeding on site and number of young	use point counts, surveys, or other protocols to determine percent of population breeding and numbers of young produced
Rare species			conduct studies as legally permitted by the jurisdictional wildlife or resource agency

CHARACTERISTIC BEING MONITORED	AS-BUILT	QUALITATIVE METHOD	QUANTITATIVE METHOD
WATER QUALITY			
Water samples (pH, salinity, nutrients, pollutants, heavy metals, etc.)	when construction is over, measure appropriate attributes based on project targets using field kits, meters, or lab analysis	on a regular basis, measure appropriate attributes based on project targets using field kits and/or field meters	on a set schedule designed to show seasonal differences, measure appropriate attributes based on project target using field meters or lab analysis
Sediment levels	use field meters or lab analysis	observe clarity and/or use a secchi disk	use field meters or lab analysis